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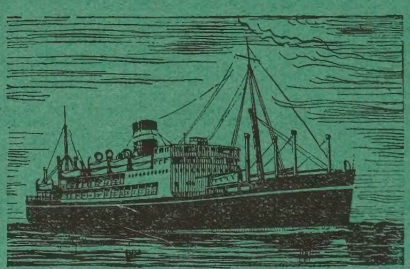

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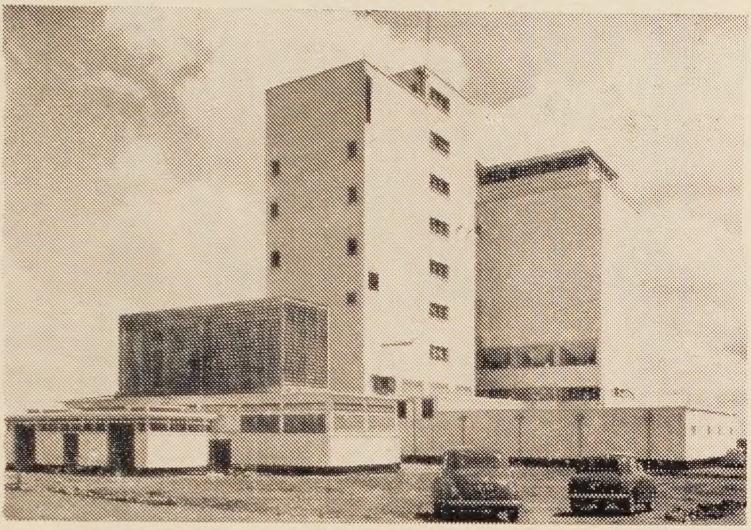

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THE ECONOMICS OF CROP PROTECTION

In a recent article under the above title (*Chemistry and Industry*, 8th January, 1955), George Ordish looks on the control of pests and diseases with the business eye of the farmer. The scientist has as his aim the complete control of a pest or disease, and although he may work out the cost per acre and the value of the crop saved, he knows that an expensive treatment may become less expensive in time, perhaps because the price of an expensive chemical will be reduced when the turnover is large, or possibly because new machinery will be devised to cut the cost of application. But the farmer must watch the financial return from his expenditure on treatment, and it may pay him better to use a method which gives 50 per cent control rather than a more expensive treatment which is completely effective.

Ordish points out that the remedies against pests and diseases are of three kinds—mechanical, biological, and chemical. By mechanical method is meant such things as extra ploughing to get rid of wire-worm, extra harrowings to try to expose insects to weather and to birds, and special times of sowing crops, such as sowing carrots late in order to avoid the carrot fly. Biological methods include the use of resistant and immune varieties of crops, and the use of parasites and predators. Chemical methods, of course, consist in applying chemicals, as sprays or as dusts, to crops in order to protect them from fungus diseases, to kill insects, or to eliminate weeds. All these methods cost money, although it is sometimes forgotten that the biological methods, though cheap to carry out once they are found, are expensive to find.

In considering an individual farm or a small farming area, the cost of the treatment and the value of the crops saved are sufficient for the farmer's purpose, but in the broader view Ordish points out that "price elasticity" must be taken into account. To explain this by an extreme example, if a large farming area had a pest which reduced the yield of its cash crop by 50 per cent, and complete control could be applied at no immediate cost to the farmer, such as by biological control, the value of the crop would not necessarily be doubled, since the greater supply for the same demand would probably lower the price of the crop and might even cause a serious glut and cause the farmer to lose money. The inhabitants of a small town in Alabama called Enterprise put up a monument to the cotton boll-weevil because they thought it had been of immense benefit to the cotton trade in that it had made cotton difficult to grow and prevented a surplus of cotton with low prices to the producer. Even recently the plum growers in England were blaming the manufacturers of tar oil winter wash because it made plums too plentiful. Against this line of argument Ordish points out that pests and diseases cause wide variations in crop yield, giving rise to shortages and gluts and making farming a gamble, whereas control of disease reduces the fluctuations in yield and enables the market to be satisfied from a smaller acreage, thereby saving land and giving the farmer a much more steady income.

We must not forget that losses in storage are just as important as losses in the growing crop, even although the farmer may not have to bear this loss directly. The Food and Agriculture Organization made a study of storage losses in wheat and rice, over the world, and found that there was a loss of 33,000,000 tons a year—enough to feed 15,000,000 people for the year.

Turning to East Africa, we are still in the stage of finding the pests and diseases and of seeking effective methods for their control. This means that when a new method of control is worked out scientifically it should be tried out practically on the farm, not only to find whether it is effective, but to find the local cost of treatment and the value of the additional crop. While the cost of hand application may be low in the more outlying farms in East Africa, the rail and lorry costs will be correspondingly high, and the real value of the additional crop is the market value less the cost of transporting it to market or to the railhead. Even in fruit-growing in England, Ordish points out that it may pay better to use one method of control which is not so effective as another in order to obtain the maximum profit per acre. But in most parts of East Africa the limiting factor in crop production is the amount and distribution of rainfall, and an expensive method of prevention of a pest or disease may seriously reduce the economic return of the crop if the distribution of rainfall is unfavourable and the yield is low because of this. In this respect cure may be better than prevention, since a pest or disease which can be controlled after it has shown signs of becoming epidemic may be treated thoroughly if the rainfall has been suitable for a large crop, and less thoroughly —if that means less expensively—if the crop prospects are doubtful.

FLUOROSIS IN CATTLE IN THE NORTHERN PROVINCE OF TANGANYIKA

By G. W. Walker and A. H. Milne, Veterinary Research Laboratory, Mpwapwa, Tanganyika

(*Received for publication on 6th April,* 1955)

The problem of fluorosis is one which has been receiving increasing attention, as is evidenced by the growing literature on the subject. With the exception of recent papers this literature has been ably reviewed by Mitchell and Edman (1952) and Schmidt and Rand (1952).

Fluorosis in humans in the areas surrounding Mount Meru in the Northern Province of Tanganyika was noted some years ago by MacGuillan (1944) and in 1952 the presence of fluorosis in cattle in the Engare Nanyuki area was brought to the attention of one of the present authors (A.H.M.).

It was decided to carry out a survey of the severity of fluorosis in cattle in the Mount Meru area and the object of the present communication is to record some of the preliminary findings, which it is hoped may be of interest to other workers in this field.

Mount Meru is an extinct volcano rising to nearly 15,000 ft. out of a plain which is strewn for many miles in all directions with volcanic ash. Numerous streams, the majority of which rapidly dry up on entering the foothills and plains, rise on the mountain. As a first step in the survey, samples were taken from these streams and analysed for fluorine content, the results being given in Table I. Fig. 1 shows the approximate positions from which the samples were taken.

It will be seen that many of these streams contained fluorine in excess of the normal maximum amount considered safe for human consumption and that several of them contained amounts which would be expected to induce fluorosis in stock.

This water analysis survey was followed up by a clinical examination of stock in three selected areas.

(a) The Engare Nanyuki Area

This area consists largely of European-occupied farms, the Engare Nanyuki river, after which the district is named, flowing through many of them. An examination was conducted on a farm which ran a dairy herd of some 200 Zebu and grade cattle which had spent most of their life on the farm and were watered at the Engare Nanyuki river. The stock were all in rather poor condition and lameness was apparent in some 20 per cent of the herd. Detailed examination of the teeth revealed extensive fluorotic lesions, virtually all animals examined showing marked pitting and staining with considerable abnormal wear of the teeth in the majority of cases. It was quite common to find animals with the incisor teeth worn completely down to the gums. Typical examples are shown in Figs. 2, 3 and 4.

TABLE I.—FLUORINE CONTENT OF WATERS
(*See Fig. 1*)

Sample No.	Name of Source	Flourine Content
		p.p.m.
1	Furrow ex. spring	4·0
2	Furrow	5·2
3	Engare Nanyuki river	31·8
4	Engare Nanyuki river	25·0
5	Tributory to Engare Nanyuki river	45·5
6	Engare Nanyuki river	24·8
7	Tributory to Engare Nanyuki river	21·5
8	Furrow off Engare Nanyuki river	24·8
9	Southern main tributory, Engare Nanyuki river	32·0
10	Northern main tributory, Engare Nanyuki river	31·8
11	Maji ya Chai river	18·6
12	Usa river	2·4
13	Magdarisha river	1·6
14	Magumira river	1·1
15	Malala river	1·1
16	Kigeri river	1·1
17	Mbembe river	2·0
18	Tengeru river	2·0
19	Unnamed stream near P.W.D. Quarry	3·0
20	Olkolola pipe line	2·6
21	Olmotoni river	5·9
22	Selian river	6·4
23	Oldonyu Sambu pipe line	14·3
24	Spring at Oldonyu Sambu	14·4
25	Temi river	2·2
26	Arusha domestic water supply	2·5

TABLE II—FLUORINE CONTENT OF BONES, CALCULATED ON BONE ASH

Rib	0·60%
Mandible	0·62%
Femur	0·58%
Last Lumbar Vertebra	0·59%
Sacrum	0·60%
Pelvic Girdle	0·62%

Exostoses were apparent on the ribs of at least 10 per cent of the animals and the owner stated that broken limbs were common; this was confirmed by the presence of some 10 animals which had obviously had recent fractures.

Bones from two animals which had died some time previously were examined. Brittleness and lightness of these bones were very marked and a rib and pelvic girdle of one animal showed obvious abnormalities. These are illustrated in Figs. 5 and 6. The

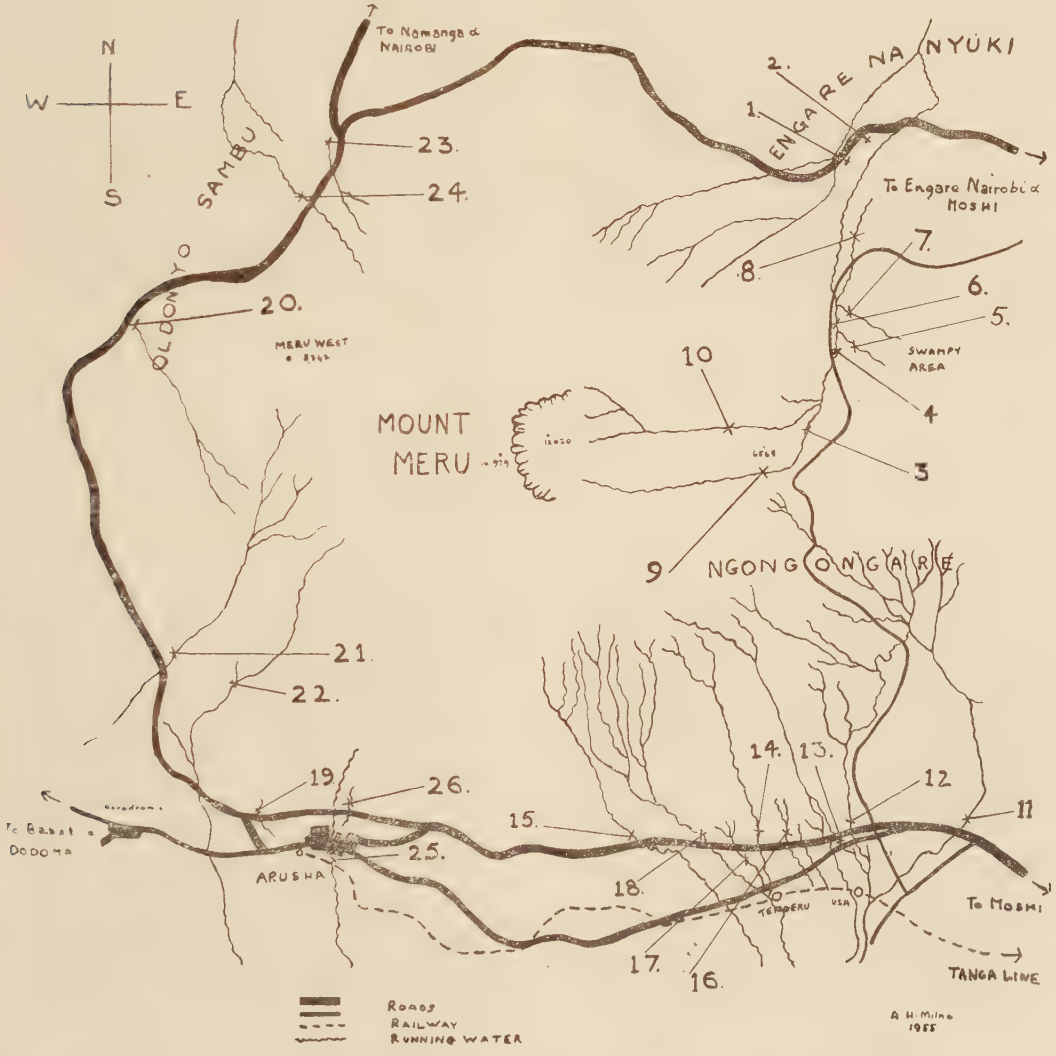

Fig. 1—Sketch map of Mount Meru area showing where water samples (Table I) were taken

fluorine content of ash from these bones is given in Table II. Urine samples were taken from two cows; these contained 12 p.p.m. and 14 p.p.m. fluorine respectively, corrected to S.G. 1.040.

Fig. 2—Engare Nanyuki area: Incisors of bovine, showing mottling and irregular wear.

(b) Maji ya Chai Area

This area which also takes its name from the river flowing through it, is an African area with a stock population which waters exclusively at the Maji ya Chai river.

Fig. 3—Engare Nanyuki area: Incisors of bovine, showing extreme wear.

Thirty animals were selected at random from some 150 cattle. Of those examined in detail, some 80 per cent showed teeth lesions of varying severity, some 45 per cent having abnormal wear of at least one tooth.

No skeletal abnormalities were noticed in either the 30 animals examined in detail or the residual 120 which were subjected to cursory examination. The animals were all in reasonably good condition.

Fig. 4—Engare Nanyuki area: Incisors of bovine, showing extreme wear.

(c) Oldonyu Sambu Area

This is a dry area to the west of Mount Meru and the principal watering point for cattle is a piped supply taken from a stream which arises several miles away in the foothills of the mountain.

Fig. 5—Abnormal rib from bovine skeleton, Engare Nanyuki area [0.60 % F.].

Some 35 cattle were examined in detail in this area and about 60 per cent showed teeth lesions which were in general very mild. No cases of severe wear were found, although slight wear was noticed in two

cases. No skeletal abnormalities were apparent and the animals were in good condition.

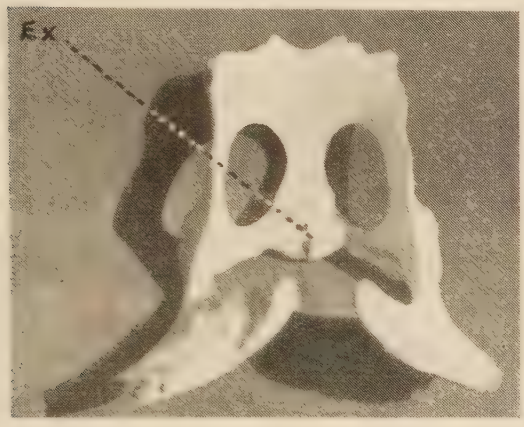

Fig. 6—Bovine pelvic girdle from Engare Nanyuki area [0.62% F.].
Ex = Exostosis on Symphysis Pubis.

It will be seen from the above that in the Northern Province of Tanganyika the critical fluorine intake for cattle appears to lie between that prevailing in the Maji ya Chai area and that in the Engare Nanyuki area. This opinion is based not on the appearance of dental lesions, but on the general health and well-being of the animal.

It is interesting to note that the fluorine content of bone ash and urine samples obtained from the Engare Nanyuki area were of a sufficiently high level to expect acute fluorosis to be apparent in the area, a supposition which was fully borne out by a clinical examination.

This work is being extended so as to obtain an accurate estimate of the actual amount of fluorine ingested in these areas, but the results obtained to date are considered of sufficient interest to be placed on record.

ACKNOWLEDGMENTS

Dr. D. W. Duthie took the photographs illustrating tooth wear, and we are grateful to him for permission to reproduce them here.

Our thanks are due to the Northern Province field staff of the Department of Veterinary Services for facilitating the examination of the cattle, and for help in the preparation of this paper we are indebted to Mr. R. W. Butler, B.V.Sc.

REFERENCES

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LABORATORY OBSERVATIONS ON THE EFFECTS OF INSECTICIDES ON THE WHITE COFFEE BORER BEETLE

By R. Foster, Colonial Insecticide Research Unit, Arusha, Tanganyika

(Received for publication on 16th March, 1955)

The White Coffee Borer Beetle, *Anthores leuconotus* Pasc., is notorious over the Northern Province of Tanganyika because of the depredation caused by the boring larvæ in coffee trees. Much field work has been undertaken in connexion with the control of the beetle, but there appears to be no previous record of laboratory work. This short paper contains the results of a preliminary investigation undertaken to determine insecticidal action in the laboratory.

Supplies of the beetle were collected almost daily during December, 1954, and January, 1955, on a coffee estate near Arusha in the Northen Province of Tanganyika. Whenever possible (about 90 per cent of the observations) the beetles were kept in the laboratory for 24 hours before use, ensuring that only the fittest were used for observations.

The insecticides employed were 0.5 per cent and 2 per cent solutions of DDT, Dieldrin, Endrin and Chlordane. All solutions were made up in olive oil, the latter substance alone being used for the control animals.

The liquids were applied to the beetles by means of an "Agla" pattern micrometer syringe. The exposure temperature was 23–25° C., and that during recovery was 21–25° C. The beetles were observed at irregular intervals after exposure, and an adequate food supply (coffee twigs and leaves) was provided both before and after treatment. Recovery took place either in closed petri-dishes or Kilner Jars.

Percentage kill or knock-down has in all cases been calculated from Abbot's formula—

$$\frac{\text{Survivors Control} - \text{Survivors Insecticide}}{\text{Survivors Control}} \times 100$$

Thus control kill or moribundness is compensated for in the expressed results. The word "significant", unless stated otherwise, is not used in a statistical sense in this paper.

Figs. 1 and 2 give the data obtained by administering 25 micrograms of insecticide to the mouthparts and the right fore-tarsi of the beetles respectively; the graphs of Fig. 1 relate to samples of 50–70 beetles, and those of Fig. 2 to samples of 40–50 beetles. In both cases the order of effectiveness is Endrin, Dieldrin, DDT and Chlordane. Previous work (Tapley, 1953) has shown Dieldrin to be approximately four times as effective as DDT in the field. It is seen from Figs. 1 and 2 that the difference between the two levels of effectiveness in the laboratory is of this order only after tarsal application. As an investigation of this nature should produce results primarily of an economic significance as opposed to a purely academic significance, it appears preferable to apply insecticide to the tarsus, and not to mouthparts, thus giving data agreeing with known field-evidence. After exposure to insecticides, the insects remain extremely moribund for a considerable time before actually dying. In this state they are practically inert, and obviously incapable of oviposition or of biting the bark; furthermore, no cases of recovery from this condition were observed. As this is the point at which the beetles have been "controlled", the time of its occurrence would appear to be a more significant value to record than that of the eventual "kill".

The results then are recorded as "percentage knock-down, control moribundness being compensated for, after tarsal application", the term "knock-down" indicating the point beyond which there is no oviposition or recovery. Figs. 1 and 2 are included as examples of method but are not significant for the economic control of the beetle.

Comparative Effect of Insecticides

Figs. 3 and 4 (all samples of 30–44 beetles) show the insecticides to fall into two groups. Dieldrin and Endrin are considerably more effective than DDT and Chlordane; there is no significant difference between the effects of Dieldrin and Endrin, or of DDT and Chlordane. Fig. 3 gives the data for a dosage of 25 micrograms. (The falls in the graphs indicate periods during which the "control

knock-down" exceeded the experimental knock-down.) DDT and Chlordane had effected only a 30–40 per cent knock-down 6–7 days after exposure. Endrin effected a 100 per cent knock-down after 63 hours; after a similar period Dieldrin had effected an 86 per cent knock-down, and the flattening of the graph between 70–142 hours is probably due to some peculiar resistance of the remaining 14 per cent of the beetles; it is not supported by other observations and is considered to be an insignificant feature of the particular experiment. Shortage of beetles prevented a repetition of the observations.

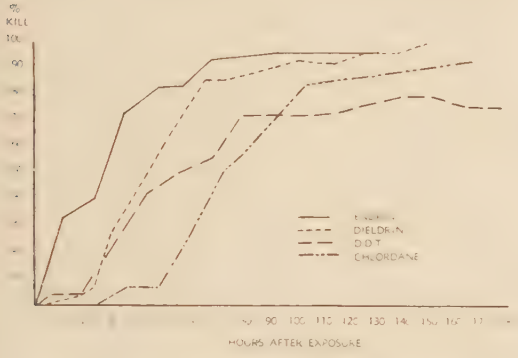

Fig. 1—Comparative effects: Oral application.

Fig. 4 relates to a dosage of 100 micrograms. DDT and Chlordane both effected a 100 per cent knock-down 65–70 hours after treatment. Endrin and Dieldrin, however, produced a similar effect after 30–33 hours.

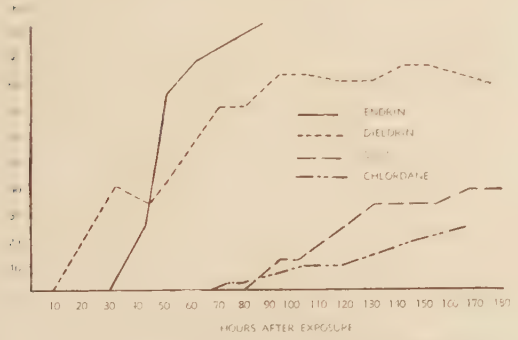

Fig. 2—Comparative effects: Tarsal application.

Thus, 25 micrograms of Endrin or (ignoring the flattening of the graph) Dieldrin produced a similar effect to 100 micrograms of DDT or Chlordane. This correlates remarkably well with the previous field observations that Dieldrin is approximately four times as effective as DDT.

The Effect on the Sexes

Twenty-three male and female beetles of approximately the same size were treated with 100 micrograms of Endrin; similarly, another 20 males and females were treated with 100 micrograms of Dieldrin. With Endrin the effect on the two sexes was very similar throughout the observation, while with Dieldrin the effects were quite indistinguishable [Fig. 5]. Thus, the sexes appear to be equally susceptible (*see* Discussion).

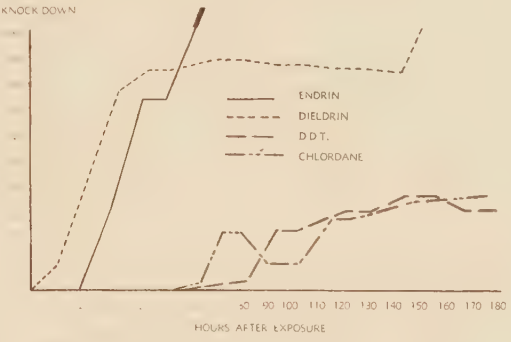

Fig. 3—Comparative effects: 25 μ grams.

The Effect of Distribution of Dosage

Thirty beetles, all of approximately equal size (about 0.7 grams), were divided into two batches of equal numbers; one batch was treated with 0.005 ml. of 2 per cent Dieldrin solution applied to the right fore-tarsus, and the other batch with 0.0025 ml. applied to each of the fore-tarsi. Fig. 6 shows the effect to be virtually similar in each batch.

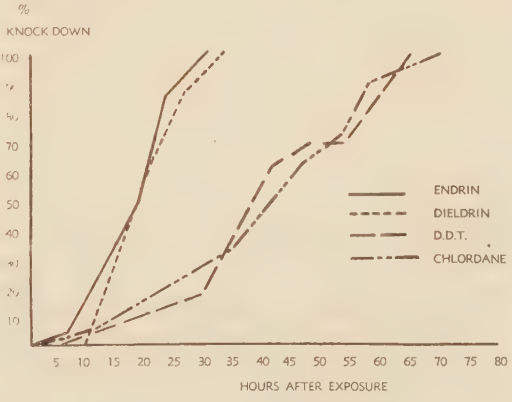

Fig. 4—Comparative effects: 100 grams.

The flattening of the graph after 20 hours is probably merely because no further observations were made until 32 hours.

Thus, the distribution of a set dose between a pair of tarsi does not alter the effect.

Minimum Knock-down Dose

An investigation to determine the minimum dose of Dieldrin and Endrin necessary to effect a knock-down showed that it is extremely small. All beetles used were of the same size (about 0.7 grams), and in Fig. 7 each graph relates to a sample of 12 beetles. Fig. 7 shows that the application of one microgram of Dieldrin to the beetles produced a 65 per cent knock-down after 114 hours. The higher dosages employed, namely 3, 5, 10 and 15 micrograms all effected a 100 per cent knock-down after various intervals, the longest being 142 hours in the case of 5 micrograms. It is not known why a dosage of 3 micrograms proved more effective than one of 5 micrograms.

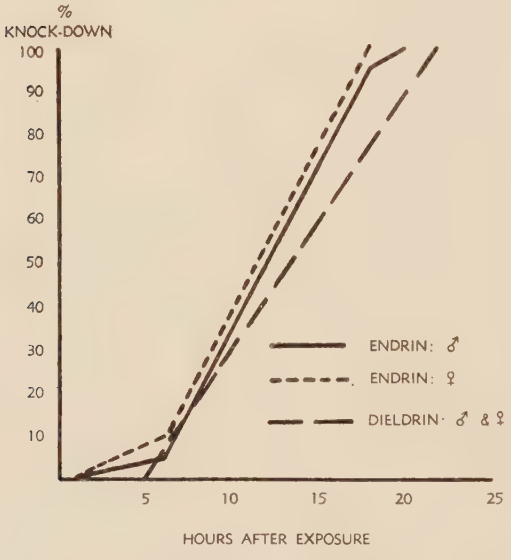

Fig. 5—Comparative effects on sexes: 100 μ grams.

A preliminary investigation of the same nature was performed with Endrin. The minimum dosage employed in this case was 5 micrograms, giving a 63 per cent knock-down after 52 hours. After the same period, 10 micrograms gave 63 per cent, 15 micrograms gave 78 per cent, and 20 micrograms gave 81 per cent knock-down. For the first 48 hours after treatment a dosage of 15 micrograms gave a greater knock-down that did one of 20 micrograms. These Endrin figures, however, are based on a small number of beetles, and may well be statistically insignificant.

Age and Susceptibility

The data recorded in Figs. 4 and 5 may conceivably indicate that susceptibility to Dieldrin and Endrin increases with age of the adult beetle.

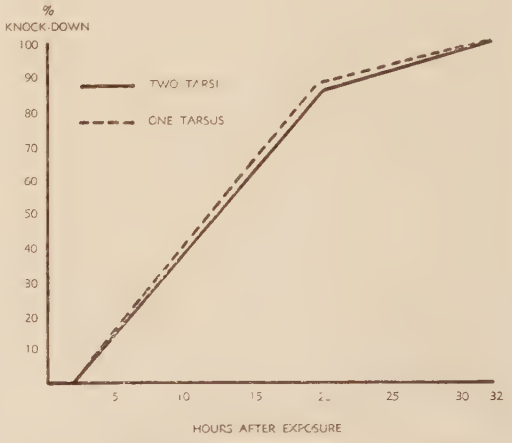

Fig. 6—Effect of distribution of dosage 100 μ grams: Dieldrin type.

In Fig. 4 the insects treated with Endrin were collected on 4th January; in Fig. 5 those treated with Endrin were collected on 17th January. Those of 4th January exhibited a 100 per cent knock-down after 30 hours, while those of 17th January, under similar conditions, exhibited a 100 per cent knock-down after only 18–20 hours.

Similarly, the Dieldrin-treated beetles of Fig. 4 were collected on 12th January, and those of Fig. 5 were collected on 27th January. The insects of 12th January showed a 100 per cent knock-down after 33 hours, while those of 27th January showed a similar knock-down after only 24 hours.

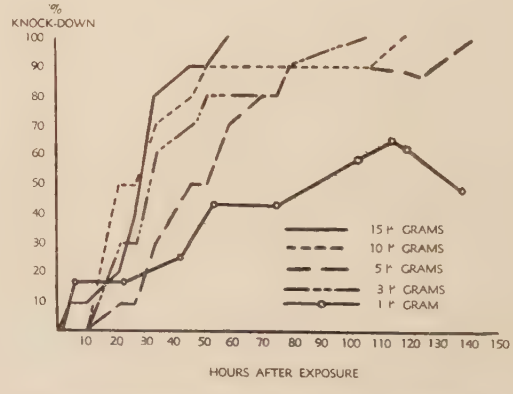

Fig. 7—Minimum knock-down dose: Dieldrin.

The assumption that beetles collected on a later date are of a greater age may well, of course, be untrue; furthermore, many environmental factors may influence the insecticidal effect. The subject obviously needs more thorough work using beetles of a known age, but the observations noted here are of interest, and possibly worthy of note.

Discussion

Although the data presented in this paper are by no means comprehensive, it is hoped that they will be of assistance to those engaged in the economic control of the beetle. The difficulties of the investigation were found to be many, and related mainly to the biology of the beetle. It is estimated that any worthwhile research project, even as described here, necessitates a supply of at least about 1,500 beetles. Even in areas of heavy infestation it is exceedingly difficult to bring this number into the laboratory as and when required; furthermore, their fighting habits necessitate each beetle being kept in a separate container. The resultant demands on labour and equipment often exceeds that available in tropical laboratories.

The main technical difficulty was found to lie in the inability to devise any system of inducing the insects to walk over a treated surface. With the methods described in this paper, the beetles undoubtedly "walked off" much of the insecticidal solution from the tarsi when they were placed in petri-dishes, and the amount of insecticide actually absorbed into the body would be but a fraction of that originally administered. The real laboratory need is for a method of making the animals walk freely on a surface treated with a known amount of insecticide. A number of methods have been tried during the present investigation, including the use of known repellants and attractants, mild chemical irritation, ultra-violet light, and the placing of male and female beetles in proximity to each other. In all cases the insects remained for the most part motionless; a solution of this problem would be a major step forward in elucidating the laboratory reactions of the species towards insecticides.

It was shown in Fig. 5 that in the laboratory male and female beetles were equally susceptible to insecticide. The reason why "... the females are particularly susceptible when they bite away treated bark..." (Tapley 1953) is considered to be due either to an increased amount of insecticide taken into the body, or a more rapid absorption, during this process. Figs. 1 and 2 showed that absorption through the mouthparts produced a greater mortality than absorption through the tarsi. If male beetles were to bite treated bark, they may well show a similar mortality, and it is hoped that future work will confirm that this "greater susceptibility" of female beetles in the field is due, in fact, to an increased intake of insecticide, and not to any sexual difference.

The adult life of the beetle is so short (about six to eight weeks), and our knowledge of it is so cursory, that every effort should be made to provide as much economic data as possible within the short period available each year. This paper will serve a useful purpose if it points the way to further work, and outlines some of the difficulties to be faced.

Conclusions

(1) Laboratory observations should be made after applying insecticide to the tarsi of the insect, and not to the mouthparts.

(2) The relative effects of insecticides in the laboratory should be assessed as "knock-down" and not as "kill".

(3) Dieldrin and Endrin are significantly more effective than DDT and Chlordane.

(4) There is no differential effect on male or or female beetles.

(5) The effect of a given dosage is not altered by distributing that dosage between a pair of tarsi.

(6) The minimum knock-down dose is very small (less than one microgram for Dieldrin).

(7) There is some indication that susceptibility to insecticides may alter towards the end of the adult life of the beetles.

Acknowledgments

Thanks are due to the officials of the Burka Coffee Estate, Arusha, for the supply of beetles, and also to Mr. R. G. Tapley of the Coffee Research Station, Lyamungu, at whose instigation the work was carried out and who provided much helpful information throughout the investigation.

Reference

Tapley, R. G., 1953. Annual report of the Entomologist, Lyamungu, for the year 1953. Annual Report of the Department of Agriculture (Tanganyika Territory), 1953. Part 2, pp. 60–62.

PLANT QUARANTINE IN EAST AFRICA

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In most territories of the world there are many restrictions governing the importation of plants from abroad which, although they may seem irksome, are designed solely for the protection of the growers of that territory. Certificates of freedom from certain pests and diseases issued by competent authorities in the exporting country are often required; importation of certain plants, or from certain territories, may be prohibited or plants may be admitted provided only that they pass through a period in quarantine upon arrival. All this is done in an attempt to prevent entry into a country of pests and diseases not already established there. The principal danger is from virus diseases, those caused by fungi, bacteria or insects being usually more easily recognized at source and more easily controlled or prevented.

Some virus diseases are mechanically transmitted; that is, if juice from an infected plant should gain entry into even a microscopic wound in a healthy plant, the latter may become infected. Such viruses can spread if leaves of a healthy plant should rub against those of an infected one in the wind and they can be passed from plant to plant on the hands or tools of labourers when disbudding, pruning, etc. However, the most important mode of transmission of virus diseases is by insects which, having fed upon a diseased plant, fly to a healthy one. Several kinds of insects carry viruses, the most frequent being aphids and leafhoppers, of both of which there are many different species. Whilst it is unlikely that any one virus would be carried by two unrelated insects, usually many species of one Natural Order of insects can carry the same virus. Even if the species described as the vector in the country of origin is not present in the importing country, there is a very good chance that the virus would find another equally effective vector there.

If a virus infects one variety of a plant species, it will almost certainly attack many related varieties and will often also infect hundreds of completely unrelated species of widely different families. The Spotted-wilt virus of tomato is known even to attack both mono- and di-cotyledonous plants:

Fortunately, viruses are not often seed-borne, and usually information is available regarding the few exceptions, so it is with vegetatively propagated material that the chief danger lies and corresponding precautions must be taken. If a new virus is imported, not only will the clone carrying it always be infected but the virus will pass to related varieties and may also infect quite unrelated crop plants. Usually, the certification system will prevent such infected material from being imported but it may fail if a plant has become infected so recently before inspection that it shows no symptoms. It may fail also in the case of symptomless carriers, which may carry diseases virulent in other crops whilst showing no ill-effects themselves. Whenever possible, propagating material is brought from countries where the phytopathological service is reliable and where the feared diseases have never been recognized. Obviously, this is not always possible; and then the only ways to guard against these dangers are either to prohibit certain importations or to quarantine the plants upon arrival in the importing country.

East Africa is fortunate in being free of some of the worst diseases which can affect agricultural crops and the Departments of Agriculture of the three territories are making every effort to prevent their entry. For example, neither the virus diseases Chlorotic-streak and Fiji disease nor the bacterial disease, Leaf scald, nor the fungus, Smut, of sugar-cane have ever been reported here. Pierce's disease of vine, which also attacks lucerne, has never been seen. Nor are the viruses of tomato Spotted wilt, aster Yellows or Curly top of sugar beet, each of which have a very wide host range, found here. It is to guard against the introduction of these and similar diseases that the East African regulations are framed and the Quarantine Station was established.

Quarantine at Amani, 1931–1951

For almost 20 years vegetatively propagated material of certain specified plants, which might be carrying diseases unknown here, were quarantined by the Pathological Department of the East African Agricultural Research

Station at Amani, Tanganyika Territory. The plants which passed through quarantine there include the sugar-cane varieties named in the appended list, and other agricultural crops such as cassava and *Agave* spp. (relatives of sisal) as well as a few ornamentals.

When the Research Station closed down and the staff were moved to Muguga to form the nucleus of the staff of the newly established East African Agriculture and Forestry Research Organization, the Quarantine Station perforce closed down and for several years the three territories were without any quarantine facilities.

The Interim Period

The loss of these facilities was a severe handicap, and the Governments agreed that the restrictions might be slightly relaxed in respect of one crop only and were willing to allow the importation of sugar-cane from the Sugar-cane Experiment Station at Mount Edgecombe only. Little advantage was taken of this relaxation and, when Chlorotic-streak disease was reported from Natal, it was decided to bring no more sugar-cane into East Africa until a new Plant Quarantine Station could be opened.

E.A. Plant Quarantine Station Established at Muguga

Realizing the need for a new Plant Quarantine Station, the three Territorial Governments agreed to share equally between them the cost of building and maintaining one. It was to be administered by the East Africa High Commission and to be sited within easy reach of Muguga so that it could be under the supervision of Pathologists and Entomologists of the E.A.A.F.R.O. staff and also share the common services of E.A.A.F.R.O. Policy would be decided by a committee consisting at present of the Senior Entomologist and Senior Pathologist of each territory under the chairmanship of Dr. H. H. Storey. In view of the frequent need for rapid decisions, a small working subcommittee, the members of which are all stationed within fairly easy reach of Muguga, was later appointed. This committee consists of the two Kenya members together with Dr. Storey and the Supervising Officer who is a Pathologist employed by E.A.A.F.R.O.

The Site

Although it was desirable that the station should be near the E.A.A.F.R.O. laboratories and to its water and electric supplies, it was also necessary that it should be isolated from the herbaceous crops grown there. A five-acre site was finally chosen beside the road connecting the E.A.A.F.R.O. and E.A.V.R.O. laboratories about one and a half miles from the former. This area belonged to the Kenya Forest Department, but they consented to exchange it for a similar area from the E.A.A.F.R.O. estate. The site is thus largely surrounded by forest which forms a useful additional sanitary cordon.

The land was cleared of trees and enclosed by a high barbed-wire fence around which a wind-break of gums and *Cupressus* sp. has been planted. The buildings are located towards the centre of the area. About half the land has been planted with *Tephrosia* sp. and the remainder, which is on a steep slope, has been terraced and grassed until it is required.

The Buildings

The layout and buildings were designed by Dr. H. H. Storey in collaboration with Mr. L. C. Martin, Maintenance Superintendent of E.A.A.F.R.O., who was responsible for the erection.

A stone building contains a small office and a small laboratory where plants can be examined, microscopically if necessary, where heat treatments can be given, small instruments sterilized, etc. There is also a small potting-room which connects through soil bins to the sterilizing room where all soil, containers and tools are sterilized by steam.

All newly introduced propagating material must be quarantined under glass. Experience of plant quarantine both in Amani and Durban had suggested to Dr. Storey the desirability of using a large number of small, separate houses. Aluminium houses made by Messrs. Crittall were imported from England. Each is 20′ × 6′ × 7′ 6″ at the apex and each has a centre glass partition dividing it into two completely independent chambers, with doors at the ends. The roof and sides down to ground level are of glass. Gauze covers over the roof ventilators and regular fumigation keep the houses remarkably free from insect pests. Each chamber has two electrically heated tubes by means of which the minimum temperature can be controlled There is no absolute control for the maximum temperature in any chamber but each is fitted with a Vent-Axia fan, and wooden slatted roller blinds. Water is laid on inside each chamber. There are at present four

The East African Plant Quarantine Station

houses of this type and four similar ones which are raised 4 ft. on stone plinths. Two more of the taller houses are now on order. The lower houses are all fitted with benches which can be removed for cleaning or if it is desired to put tall plants in these houses. The taller houses are usually reserved for the larger plants which are grown in 20-gallon drums. These are raised to the level of the top of the stone plinth and are then gradually lowered as the plants gain in height.

Staff

The Station opened on 1st January, 1954, in charge of a European Horticulturist. About four African staff are necessary. Quarters for African staff were built on the site, but owing to their relative isolation and proximity to Muguga Forest it has been necessary to close them during the Emergency and to house the staff in the E.A.A.F.R.O. labour camp.

Procedure

Plants can be quarantined only at the request of one of the Departments of Agriculture. Growers wishing to import plants should apply to the department in their territory; and if quarantine is a necessary condition for the issue of a permit the department will make the necessary arrangements. Importers must clearly understand that if plants are found to be carrying disease and have to be destroyed, no compensation will be paid either by E.A.P.Q.S. or by the territorial Department of Agriculture.

The general policy is to import as many new varieties as possible. With limited glasshouse accommodation this means that only a very few plants of each variety can be quarantined. However, they will multiply to some extent whilst in quarantine and, once released, can be rapidly multiplied up by the importer. If any one plant of a variety is infected, all plants of that variety will be destroyed and, in some cases, all plants in the same glasshouse chamber or of the same consignment. It is obviously undesirable to mix different consignments together in the same chamber; so to use the space most economically, each consignment should fill a chamber. The number of plants which will fill one of these chambers will vary with the species, and the grower wishing to import plants will be told how many he may bring and also the maximum number of any one variety.

Upon arrival, all plants are inspected for any visible signs of disease or insect pests, and, as an additional precaution, are treated with an insecticide and a fungicide before planting. The plants are potted in sterilized containers in compost which has been sterilized and stacked. In one single situation, it is obviously impossible to give ideal cultural conditions to every different species which may be imported, but every effort is being made to provide the best possible. This is done, not only so that the plants may multiply whilst in quarantine, but also because symptoms of virus disease are more likely to become evident and be diagnosed with greater certainty than if the plants were poorly grown. As the first importations have been slow in arriving, the opportunity has been taken to experiment with cultural methods for some of the expected species under the conditions at Muguga. Experimental importations have been obtained from Europe in order to do this. All glasshouses are regularly fumigated with benzene hexachloride and with azobenzene, and any other treatments which may seem desirable are given. After use, all soil, containers, tools, instruments, etc., are sterilized by steam, and glasshouses are thoroughly cleaned and fumigated before a new consignment is put in.

In some cases, diagnosis of disease must rely solely on frequent inspection of the plants; in other cases, certain tests may be made and, in yet others, curative treatment may be applied. Examples of each of these methods will be seen in the details of individual species which follow.

Importations

It is impossible to forecast exactly how the Quarantine Station will be used, for it will depend on trends of agriculture in East Africa; but it is expected that many different species of agricultural crops and some few ornamentals will pass through it. Some account of what is now being held in quarantine and of the programme for the immediate future will give an indication of the methods used and of the general principles involved.

Sugar-cane

At present the taller houses are filled almost to capacity with the sugar-cane listed in the Appendix, for new varieties of this seemed to be East Africa's most urgent need. Other plant species are imported either by a Department of Agriculture or by a grower under permit from a department and, if they are to be quarantined, they travel direct from the

exporter to the Quarantine Station. Sugarcane is the exception; for many reasons it seemed desirable for E.A.A.F.R.O. to arrange the consignments of this. Varieties chosen are either those suggested by the departments or those which experienced growers have suggested as being suitable for the conditions prevailing in East Africa. Every effort is made to obtain the cane from reliable sources whenever possible from Experiment Stations, and it always carries a health certificate. It always comes by air-freight and in only one case, when the parcel was delayed for some six weeks, has there been any failure in germination. Two setts only of each variety are imported; these are planted together in a 20-gallon drum. As six such drums can be kept in one glasshouse chamber when the cane is fully grown, importations usually consist of six different varieties. The plants are retained for a minimum of one year, during which period they are frequently inspected by a pathologist.

At Amani, if a plant was found to be infected, both it and its contacts were immediately destroyed; but now there is more information regarding diseases of cane it may be possible to judge each case individually. For example, if a clone showed symptoms of Mosaic disease or of Streak, both of which are widespread in East Africa, it would be destroyed, for its progeny would always carry the virus. It might be possible to retain its contacts in quarantine for a longer period than the minimum and, if after a reasonable time they showed no symptoms, to release them. If Leaf scald or Fiji disease appeared, neither of which is known on the African continent, the plant and its contacts would be immediately destroyed, for no cure is known for either of these diseases. Should Chlorotic streak be diagnosed, action would probably depend on the age of the plant. Normally the plant and its contacts would be immediately destroyed. But this disease can be cured by holding the setts in warm water for a stated period of time before planting; and if, when the plant showed symptoms, it was sufficiently mature for setts to be cut, these might be taken from it and from all its contacts before they were destroyed. Heat therapy would be applied and the new plants retained for a further minimum period of one year under glass. If the plants were not sufficiently mature for setts to be taken, the varieties would have to be re-imported. The symptoms of Ratoon-stunting disease are obscure, and would be impossible to diagnose whilst the plant was in quarantine, especially as there would be no healthy plants of the same variety with which to compare it. Stunting might easily be due to its being grown under conditions not suited to the variety.* This disease can be cured by heat treatment and as a precautionary measure all cane will be so treated before it is released from quarantine. The treatment is more severe than that required to inactivate the virus of Chlorotic-streak disease and must be exactly controlled since temperatures very slightly higher than those needed to cure the disease will kill the cane. Experiments have been made in several countries in varying the temperature, using moist as against wet conditions and in varying the period. It has been shown that the treatment which is certain to inactivate the virus and is least likely to injure the cane is to hold the setts in water at 52° C. for 1½ hours. The cane is more likely to survive if the treatment is given immediately before planting. As the cane received in E.A.P.Q.S. has always been a number of days or even weeks on the journey, it was felt that its chances of survival if heat-treated on arrival would be slight and so it was at first intended to give the treatment immediately before the setts were despatched to the three territories. However, by the kindness and co-operation of the Uganda Department of Agriculture a better method has been devised. It has for some time been known that Ratoon-stunting disease is widespread in East Africa, and Uganda is making every effort to clean up the cane in that territory. The entire cane collection held at the Kawanda Experiment Station was destroyed and no variety is now planted there unless it has been treated for Ratoon-stunting disease. They have agreed to accept all cane released from the Quarantine Station. On an agreed date a consignment will be sent to them by air and they will apply heat therapy and plant it out at once. There should thus be an interval of only about 24 hours between the cutting of the cane at Muguga and its planting out at Kawanda for multiplication. It will then

* This has already occurred. The variety "Trojan" was received into quarantine. After ten months, the longest stem had produced 20 internodes compressed into 14 inches. As the cause was unknown, it appeared too dangerous to keep the plants and they were destroyed. Subsequent inquiry in Australia revealed that this variety demands a long day and a rich, well-watered alluvial soil, and thus is totally unsuited to conditions in East Africa.

have what is virtually a further year's open quarantine before being distributed to the Kenya and Tanganyika Departments of Agriculture.

It is intended to hold at the station a collection of all the cane varieties which pass through quarantine there. Simultaneously with the setts being despatched to Kawanda, four setts will receive heat therapy at Muguga before being planted out. The original roots in the drums will be allowed to ratoon until it is known that the varieties are established at both stations. Distribution to growers will be through the Department of Agriculture in their own territory. Kawanda will distribute to the Uganda growers and to the other two departments. After the first despatch to Kawanda, the Quarantine Station will hold very little stock but will always be willing to send a few setts to experimental stations abroad on an exchange basis.

Ornamentals

Some ornamental plants are symptomless carriers of one or more viruses. Probably the most important virus carried this way is that causing Spotted wilt of tomato, for it also attacks several hundreds of widely different host plants causing very serious diseases in many of them. It attacks tobacco, lettuce, celery, cauliflower, potato, Cape gooseberry as well as many other solanaceous and leguminous plants of economic value and many ornamentals and weeds. The virus, which is carried from plant to plant by several species of thrips, has once been reported in East Africa but prompt action stamped it out.* When being imported into East Africa all known host plants need to be accompanied by a certificate of freedom from this virus. It is impossible for an Inspector to issue such a certificate for dahlia, chrysanthemum, begonia and arum lily, which when infected show only faint symptoms or none at all. In the absence of quarantine facilities the Governments of East Africa were obliged to prohibit entirely the importation of these plants.

Since the opening of the E.A.P.Q.S. they have decided to allow the importation of small numbers of these plants which will go straight into quarantine on arrival and there be tested for the presence of virus. All those viruses which these plants are known to carry without showing symptoms can be transmitted mechanically; this fact, together with the knowledge that the same viruses produce characteristic symptoms in other host plants is used in designing the tests. The imported plants are grown until it is possible to tear from them small pieces of several leaves. These are crushed together in a sterile mortar with a sterile pestle to extract the juice. The juice is usually extracted into water but in some special cases this is replaced by a reducing agent such as 0.5 per cent solution of anhydrous sodium sulphite. The juice is then rubbed lightly but firmly over the surface of several leaves of the test plant. It is often advisable to use a mild abrasive such as carborundum or a diatomaceous earth; this can be either added to the inoculum or sprinkled lightly over the surface of the leaf before it is inoculated. Suitable plants to use for these tests are small rooted cuttings of petunia, or seedlings of tobacco or of *Nicotiana glutinosa*. If Spotted wilt only is being tested for, detached leaves of petunia can be used and, if they are kept moist in a petri dish, will give a result in two days. As we are interested in testing also for other viruses, we usually use rooted cuttings and inoculate several leaves of one plant from the inoculum made from a single suspect. Each imported plant is tested separately. If, after one month, all the test plants have given negative results, the tests are repeated and if the second series of tests are all negative, the plants will probably be released. If either series of tests shows one plant to be infected, all plants of that variety will be destroyed. These tests are not adequate for chrysanthemum in which some viruses seem not to be fully systemic (i.e. all tissues are not invaded by the virus) or may be difficult to extract, as the virus seems to be inactivated by the plant juice in the process. Testing by this method can therefore be rather chancy and the results of several series of tests may be very inconsistent. It has therefore been decided to test each chrysanthemum plant six times at intervals of one month. If the plants are to be released, the tests must give a negative result every time and, if any plant gives a positive reaction, all the plants of that variety will be destroyed at once.†

* Wallace, G. B., 1947. Kromnek Disease. *E. Afr. agric. J., 13,* 103–6.

† The first consignment of chrysanthemums received consisted of six varieties, none of which showed any virus symptoms in the foliage, but tests showed five of the varieties to be carrying a virus. It was probably that causing tomato-Aspermy disease. This virus has many hosts. It either spoils or prevents the production of tomato fruits; it may distort chrysanthemum flowers and also causes a severe disease in tobacco.

Chrysanthemums will thus take at least six months to pass through quarantine: other species should pass through in rather less time, depending on how long they take to produce sufficient growth for it to be possible to take material for preparing the inoculum without injury to the plant.

As these viruses are mechanically transmitted, care must be taken that no two plants touch each other; and, having regard to the size they will attain before release, it will be possible to keep only about 25 such plants with a test plant standing beside each in one glasshouse chamber. In order to make the best use of available space, it has been suggested that each consignment should consist of 24–25 plants and should contain not more than five to six plants of any one variety. If the importer chooses, he can bring in a greater number of varieties provided he brings fewer plants of each so that the total does not exceed 25. If a variety has once passed through the Quarantine Station, it cannot be imported again unless the circumstances are very exceptional.

It is expected that new techniques will have to be evolved for each new species imported. It must be realized that the East African Plant Quarantine Station is still in an experimental stage and that the procedures outlined here may well have to be modified when they have been more fully tried out.

APPENDIX

The following are lists of sugar-cane varieties known to be in East Africa. The initial letters before the numbers indicate the country of origin as follows:—

B.	Barbados.
Ba.	Barbados.
BH.	Barbados Hybrid.
Co.	Coimbatore, India.
CP.	Canal Point, Florida, U.S.A.
D.	Demarara, British Guiana.
FC.	Fajardo Central, Puerto Rico.
H.	Honolulu, Hawaii.
HM.	Hebbal, Mysore, India.
M.	Mauritius.
MF.	Mauritius (Fodder cane).
Myaguez.	Puerto Rico.
NCo.	Seedlings raised in Natal from seed from Coimbatore.
POJ.	Proefstation Oost Java.
PR.	Puerto Rico.
RP.	Seedlings raised by a planter in Demarara.

In the first two lists the varieties are followed by letters to show where they are located in East Africa.

K.	Kisumu, Kenya.
T.	Chambezi, nr. Bagamoyo, Tanganyika Territory.
U.	Kawanda, nr. Kampala, Uganda.

Sugar-cane Varieties Passed Through the Amani Quarantine Station, 1931–51

When the Amani Quarantine Station closed down, the sugar-cane collection held there was destroyed but most of the varieties which passed through it are still available in East Africa. These are listed below:—

B	726	KT	Co	426	KT
B	891	KT	Co	432	KT
B	2935	KT	Co	434	KT
B	3013	KT			
B	3172	KT	CP	807	KT
B	3215	KT			
B	3254	KT	D	625	KT
B	3257	KT			
B	3337	KT	FC	915	KT
B	3439	KTU			
B	4362	KTU	HM	320	T
B	34104	KTU	HM	606	T
B	34105	KT			
B	34106	KT	M	72/31	KT
B	34110	KT	M	73/31	KT
B	34120	KT	M	134/32	KTU
B	34123	KT	M	171/30	KT
B	34129	KT			
B	34137	KT	MF	1/40	KT
B	35151	KT	MF	2/40	KT
B	35176	KT			
B	35179	KT	Myaguez	3	KT
B	35187	KT	Myaguez	7	KT
B	35221	KT	Myaguez	28	KT
B	35237	KT	Myaguez	42	K
B	35245	KT	Myaguez	49	KT
B	37159	T	Myaguez	61	T
B	37161	KU	Myaguez	151	KT
B	37173	T			
B	37193	K	NCo	79	T
B	37194	T	NCo	291	T
B	37254	T			
B	37260	T	POJ	213	KT
B	41211	KU	POJ	2714	KT
B	41227	KTU	POJ	2725	KTU
			POJ	2727	KT
Ba	11403	KT	POJ	2747	KT
Ba	11569	T	POJ	2803	KT
			POJ	2875	KT
BH	10/12	T	POJ	2878	KTU
			POJ	2961	KTU
Co	205	KT			
Co	213	KT	PR	803	KT
Co	244	KT	PR	809	KT
Co	285	KT			
Co	301	KT	RP	8	KT
Co	312	KT			
Co	331	KTU	Badila		TU
Co	360	KT			
Co	404	KT	Diamond	10	T
Co	407	KT			
Co	408	KT	Kavangiri		T
Co	411	KT			
Co	417	K	Uba		T
Co	419	KTU			
Co	421	KT			

Sugar-cane Varieties Also Available in East Africa

The following were imported and quarantined by the Kenya Department of Agriculture during the interval between the closing of the Quarantine Station at Amani and the opening of that at Muguga:—

Co	290	K	CP	36/105	KU
Co	421	KU			
Co	453	K	NCo	310	KU
			NCo	330	U
			NCo	334	KU
CP	34/79	KU	NCo	339	KU
CP	34/120	KU	NCo	349	KU

Sugar-cane Varieties Admitted to E.A.P.Q.S. During 1954

B	4098	M	112/34
B	37172	M	165/38
		M	423/41
Co	396		
Co	475	NCo	292
Co	513	NCo	293
Co	602		
Co	617	*Pepe Cuca	
H	32/8560	POJ	3016
H	38/2915		
H	38/4443	PR	905
H	39/3633		
H	39/5803	*PR	1000
H	39/7028		
H	44/3098	†Trojan	

* Release delayed.

† Destroyed.

REVIEW

PROCEEDINGS OF THE BRITISH SOCIETY OF ANIMAL PRODUCTION, 1954, edited by I. L. Mason and G. Wiener. Obtainable from the Scottish County Press, North Wynd, Da'keith, Midlothian, Scotland. Price 15*s*.

Some sixteen papers are included in the 1954 *Proceedings* dealing with beef and dairy cattle, sheep, pigs and poultry, and discussing such problems as liveweights, feeding, management, anatomical measurements, genetics, progeny testing, and the selection of breeding stock. To cover all aspects in a short review is impossible and the aim has been to comment on certain papers which have a greater immediate interest to local readers. This selection is not intended to reflect on the quality of the other papers and a study of the *Proceedings* can confidently be recommended both to research workers and to farmers.

The need to estimate liveweights accurately is an essential prerequisite to the use of liveweight changes for assessing grassland productivity. J. C. Tayler shows how liveweights are complicated by "fill" at any particular time and illustrates, from fasting studies and the alimentary contents at slaughter, the correlation between weight losses after six hours' starvation and those after 24 and 86 hours. He indicates how such 6-hour figures can be used to calculate fasted liveweights in sheep and cattle. J. L. Corbett discusses the maintenance of store cattle solely on winter pastures. J. C. W. Jones shows the good consumption rates of six types of crossbred sheep are not significantly different and discusses this in relation to the general stratification in the sheep industry. J. C. Gill and W. Thomson indicate that, under cultivated grazing conditions, supplementary feeding during the first winter of life was not of subsequent benefit to breeding ewes.

D. M. Joubert finds thickness of muscle fibres is related to total muscle weight in the carcass and is a function of physiological and not of chronological age. Differences in meat texture and quality are attributed to factors other than muscle fibre size. E. T. R. Evans corroborates the considerable variation in vertebral numbers in pigs and indicates the scope for improvement in the lumbar region of Welsh pigs. He suggests that X-ray counts on weaners could be of benefit for improving pig-breeding policies.

G. Wiener suggests there is little prospect of deliberate genetic advance in flocks of short duration and that the best opportunities for selection of economic characters of low heritability lie in the larger and older flocks. A. G. T. McArthur discusses a method for improving the evaluation of bulls and cows based on their "relative genetic value" and I. L. Mason shows that bulls can be selected more easily, on the basis of their daughters' milk yields, in good than in poor herds. A. Robertson reports the effects of father-daughter breedings in British Friesians and shows that, while fat percentage and age at first calf are unaffected, there is a significant decrease in milk yield. A. E. Maddison illustrates how a greater rate of progress can be secured by selection on partial than on full year egg records or on an index constructed from the bird's own record and the average of six full sisters.

M.H.F.

THE FEEDING VALUE OF SWEET POTATO TUBERS

By M. H. French, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.

(*Received for publication on 18th April, 1955*)

Roots have long assumed an important place in the winter dietaries of stock in Europe, but their usefulness in East Africa is limited by the climatic zones in which they can be grown. Tubers, such as cassava, canna, and sweet potatoes, are more adaptable than roots to local environmental conditions, particularly at lower altitudes, and it is of importance to determine their usefulness for livestock. Studies have already been made of the composition, digestibility and feeding values of the two former varieties of tubers and this article completes the story by adding the data concerning fresh sweet potatoes. The material employed was purchased from African producers and had an average moisture content of 41 per cent. The dry matter composition is compared in Table I with the corresponding data for fresh canna and cassava tubers.

TABLE I.—PERCENTAGE COMPOSITIONS OF TUBERS
(*Dry Matter Basis*)

	Sweet Potatoes	Cassava	Edible Canna
Crude Protein ..	5·13	3·63	3·60
Ether Extract	1·08	1·02	0·78
Crude Fibre	2·30	5·02	3·39
N-free Extract ..	87·53	85·40	84·78
Total Ash	3·46	4·93	7·45
SiO_2	0·36	0·43	0·74
SiO_2-free Ash ..	3·10	4·50	6·71

The analysis of the sweet potato tubers compares favourably with data from other parts of the world. Their dry matter is less fibrous and poorer in mineral matter than the dry matter of cassava and canna tubers, but is slightly richer in crude protein. All these tubers are highly carbonaceous and rich in starch.

The digestibilities of the tubers were determined by feeding with a chaffed hay of known digestibility to native sheep. The aim was to feed the tubers and hay in a mixed ration, which would allow the sweet potato dry matter to form one-third of the total intake, but the sweet potato dry matter ultimately worked out at 31.5 per cent of the total consumption. No digestive troubles were encountered during the 12-day experimental period and the ration was consumed completely. The daily allowance of sweet potatoes was weighed out every morning from freshly chopped tubers and was thoroughly mixed with the chaff before feeding.

The digestibilities of the organic matter by the two sheep agreed very closely but, as is common when adding a carbohydrate food to chaffed hay, the agreement between the individual animals for the digestibility of the ether extract and crude fibre constituents was erratic. Because this disturbance was anticipated from previous experiments, the proportion of sweet potatoes in the ration was higher than would normally be used. To illustrate this divergence in net digestibility, or more likely the disturbance in the digestibility of the basal hay ration due to the consumption of a succulent carbohydrate food, the percentage values are quoted:—

TABLE II.—DIGESTIBILITY OF SWEET POTATO TUBERS
(*SiO_2-free Dry Matter Basis*)
Hay Dry Matter Eaten —4,259·32 g.
Tuber Dry Matter Eaten—1,992·80 g.

	Percentage Digestibilities		
	Sheep L	Sheep M	Average
Crude Protein ..	38·14	36·84	37·49
Ether Extract	41·62	61·57	51·60
Crude Fibre	63·89	94·80	79·34
N-free Extract ..	95·50	95·49	95·50
Dry Matter	85·02	86·72	85·87
Organic Matter ..	91·97	91·97	91·97

Although there is a marked difference in the digestibility coefficients of the fibre and fat between the sheep, these two components form such a small percentage of the total dry matter contributed by the sweet potatoes that the divergence does not significantly affect the nutritive values. Table III gives the average digestible nutrient content and the calculated starch equivalent values obtained by deducting 0.29 times the crude fibre content in accordance with Kellner's procedure.

TABLE III.—DIGESTIBLE NUTRIENTS AND STARCH EQUIVALENT VALUES
(*Dry Matter Basis*)

	Sweet Potatoes	Cassava	Edible Canna
Digestible Crude Protein	1·93	0·70	1·60
Digestible Ether Extract	0·56	0·86	0·49
Digestible Crude Fibre	2·23	3·89	3·01
Digestible N-free Extract	83·90	81·90	76·06
Starch Equivalent ..	88·01	86·38	80·53

These figures emphasize the essential carbohydrate nature of these tubers and the need to feed them in rations which will adequately correct their deficiencies of crude protein and minerals. Provided care is taken to correct these deficiencies, the tubers are valuable energy contributors while their succulence and high digestibility will help improve the feeding values of the rations with which they are incorporated. Because of their essential carbohydrate nature, they will have a hardening effect on carcass fat when fed to bacon pigs, and the only preparation necessary is to chop the tubers into convenient sizes.

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FERTILITY AND INFERTILITY IN THE DOMESTIC ANIMALS, by J. A. Laing. Published by Bailliere, Tindall & Cox, 1955. Price 35*s*.

One, but by no means the only, important contribution of this book is the collection within 247 pages of a vast quantity of world information on fertility and sterility problems which would otherwise take a long time to discover and read in scientific journals. This well-prepared and easily read book makes a timely appearance when so many veterinarians, agriculturists and physiologists are so actively engaged in assisting farmers to avoid or combat the serious consequences of infertility in their flocks and herds in order to raise the economic productivity of their commercial animals.

After a general introductory chapter which reviews the main problem and lines of thought, the author discusses the physiology of normal reproduction in males and females. This is followed by descriptions of the normal genitalia in both sexes and by clinical observations in the female during pregnancy. Artificial insemination is then discussed from the practitioner's angle, followed by clinical observations on such organisms and their infective manifestations as Brucella, Trichomonas, Vibrio. Tuberculosis and other infections of the genitalia are then reviewed and the last chapter gives a brief summary of malnutritional interferences with reproductive activities. The main emphasis throughout is on cattle and horses but the pig, sheep and dog are discussed and described when appropriate.

HYDROPONICS: THE BENGAL SYSTEM, by J. Sholto Douglas. Oxford University Press (London: Geoffrey Cumberlege), 1951. Price 10*s*. 6*d*.

In this book of 147 pages the author gives details of a method of growing plants without soil which avoids many of the difficulties of the older methods. When plants are grown in nutrient solutions the delicate chemical balance of the plant foods is easily disturbed, and good luck or constant chemical control is necessary in order to achieve success. In this system the medium consists of rock chips and rock dust, and the chemicals are supplied as commercial fertilizers, water being supplied as intermittent irrigation. This method is much less liable to involve technical difficulties than those in which pure chemicals are used, and although some control of acidity is advisable, a very simple test is sufficient for the purpose.

The author is to be congratulated on producing a method of soilless culture which is simple to set up and inexpensive to run. Details of other systems, in which pure chemicals are used, are also included for reference, but preference is rightly given to the simpler method using fertilizers.

D.W.D.

MALICIOUS ARSENIC POISONING IN FOWLS

By Yvonne L. Malherbe, Department of Veterinary Services, Kenya

(*Received for publication on 28th April,* 1955)

Despite the widespread use of arsenical preparations by the farming community for the control of pests, accidental arsenical poisoning of fowls is rare. In Kenya during the last 40 years, five sporadic deaths have been reported as being due to arsenical poisoning (Walker, 1924; Beaumont, 1950, 1951). Similarly, elsewhere, the condition has only been observed occasionally (Clough, 1927; Wyssmann, 1945). The effects of malicious poisoning were strikingly demonstrated in a Kenya poultry flock during March, 1955, and are herein reported.

Symptoms

Deaths occurred within a few hours of feeding often without observable symptoms. Some birds had ruffled feathers and an increased thirst prior to death. The surviving birds in the affected pens were visibly sick. Approximately 127 birds had access to the arsenic and 30 died (24 per cent). The egg production dropped suddenly by 50 per cent but recovered quickly except in the two worst affected pens.

Post-Mortem Findings

Thirteen carcasses were submitted to the laboratory for examination. The characteristic and most striking lesions were in the gizzard. These varied from slight erosion of the mucous membrane which was very friable, to a raising of the membrane by a white, gelatinous fluid. The subepithelial layer of the gizzard was inflamed. Severe enteritis with sloughing of the mucous membrane was present in all the birds. The livers showed streaky areas of fatty degeneration. Orange discoloration of the fat as described by Schwarte (1952) was not noticed. All combs and wattles were cyanotic. There were no other pertinent lesions.

Laboratory Findings

Pathogenic bacteria were not isolated. Specimens of the livers, gizzard, gizzard contents and the intestines were tested by the Gutzeit method for arsenic and proved to be positive. Samples of the mash and pellets out of half-used bags; mash taken from the troughs; and water from the drinking-pans were tested. The water, the pellets and the mash from the bags were negative but arsenic was demonstrated in the mash from the troughs of three pens.

Discussion

Experiments in Africa (van Zyl, 1929; Chorley and McChlery, 1935) and America (Wilson and Holmes, 1936; Whitehead, 1938) showed that fowls would refuse to eat poisoned locust or grasshopper bait and would not consume sufficient poisoned insects to cause death. The rarity of arsenic poisoning confirms these experiments. Nevertheless, malicious poisoning is possible and can be disastrous. Townson and Gordon (1938) recorded the loss of 120 birds out of a flock of 150. Unfortunately, they had only two birds available for post-mortem examination but both exhibited the characteristic lesion of the gizzard. The lesion is apparently pathognomonic but it is not invariably present. Only six out of thirteen cases examined at Kabete had the mucous membrane raised from the wall of the gizzard by a sero-gelatinous fluid. As in other species, the diagnosis must rest on the demonstration of arsenic in the intestinal content and in the tissues.

SUMMARY

Thirty out of 127 fowls died from arsenic poisoning, maliciously administered. Thirteen birds were post-mortemed and six exhibited the characteristic lesions of the gizzard in which the mucous membrane was raised from the wall by a sero-fibrinous exudate. Arsenic was demonstrated in the intestinal contents and tissues of the affected birds.

ACKNOWLEDGMENT

I am indebted to Mr. D. P. Braithwaite for carrying out the Gutzeit arsenic tests, to Mr. G. R. Scott and Mr. J. W. Macaulay for advice and assistance with this communication, and to the Director of Veterinary Services, Kenya, for permission to publish this report.

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REVIEW

GENETIC HOMEOSTASIS by I. M. Lerner, published by Oliver and Boyd, Edinburgh, 1954. Price 12*s.* 6*d.*

This book, which is primarily produced for geneticists, discusses the self-regulating properties of Mendelian populations to equilibrate their genetic compositions and to resist sudden changes. The thesis advanced is that heterozygosity in Mendelian populations is a mechanism for maintaining genetic reserves while permitting a large proportion of the individuals to exhibit combinations of phenotypic properties near the optimum. Consequently, the ability of a population to fit its environment is favoured by the superior buffering ability of heterozygotes which automatically increases its capacity to carry genetic reserves.

M.H.F.

CORRIGENDUM

In the article "Tree Growth on a Seasonally Dry Swamp in Eastern Uganda" by J. E. M. Stephens, Vol. XX, No. 4, April 1955, page 232, the captions under Figs. 4 and 7 should be interchanged, reading: —

Fig. 4—Root profile of *E. saligna* in seepage soil. Height of tree about 35 ft.

Fig. 7—Root profile of *C. siamea* on swamp bottom soil. Average height of surrounding trees 38 ft.

THE CITRUS BUD MITE, ACERIA SHELDONI (EWING) ERIOPHYIDAE IN KENYA

By R. Le Pelley, Department of Agriculture, Kenya

(*Received for publication on 25th May, 1955*)

In 1955 the citrus bud mite was first recognized in this country on grapefruit and lemon trees in a small planting of citrus trees in Lower Kabete. Following this, observations were made by Entomologists and Agricultural Officers which showed that the pest is widely spread in this country, occurring at the Coast (Matuga), in the neighbourhood of Nairobi (Kabete, Kiambu), in Nyanza (Kibos), at Endebess and many other places. Its origin is not known, though it was probably received in the first place from South Africa whence comes most of our citrus planting material. In South Africa this mite was first recorded from Rustenberg in 1952 (Munro *in litt.*) but the South African authorities do not yet know the limits of its spread in the Union, though it is known to be present in the Northern Transvaal. It has been found in Kenya heavily attacking young nursery stock recently imported from South Africa. From the condition of very old lemon trees growing near Nairobi it seems likely that it has also been present in this country undetected for many years.

Distribution

This Eriophyid Mite was first discovered in Southern California in 1937. It was then an undescribed species but according to Boyce Korsmeier and Persing[1] it had probably been present in the States for many years. Since its discovery in California it has proved to be widely spread, being known from Hawaiian Islands (Oahu), Australia (Queensland, New South Wales), North America (California), Europe (Italy, Sicily), Africa (Northern Transvaal, Southern Rhodesia, Kenya) and from Cyprus, Lebanon, Israel and Turkey.

Host Plants and Nature of Injury

The Mite is minute and only visible under magnification, but the damage is so marked as to be symptomatic of citrus bud mite infestation. In all cases where this damage has been noted in Kenya bud mites have been found on examination to be present. Fruit deformities of exactly the same type as are now known to be caused by the bud mite, were illustrated as

Fig. 1—Shoot showing twisted growth.

Fig. 2. Shoot showing damaged buds and deformed leaves.

Fig. 3—Lemon fruit showing deformed growth.

Fig. 4—Shoot showing multiple branching following control of the bud mite on this shoot.

[*Photos R. A. Robinson*

long ago as 1646, these early illustrations being reproduced again in a recent paper in *California Agriculture* (Jeppson and de Pietri-Tonelli).[2] The mite induces a distortion of leaves, shoots, buds, flowers and fruits, and this is often so severe in this country that the growth of the tree is almost entirely inhibited. It is one of the chief causes of the poor growth made by much of the citrus here. The mite appears to be confined to citrus, the attack in Kenya being most severe on grapefruit, but also bad on lemons and sometimes on navel oranges.

Habits and Life History

The mites live in protected places within the buds, between the leaf petioles and the bud, under the bottoms of fruits, in fact anywhere on the foliage or young twigs where they can find niches offering shelter. Details of the length of life have not yet been ascertained in Kenya but the following details by Boyce Korsmeier and Persing[1] from California may be quoted: The incubation period is stated to vary from two to six days depending on prevailing temperature. There are four developmental forms of immature mites and the total development period from egg to adult is between 10 to 30 days, being about 15 days during the fall season. It is likely, therefore, that in citrus areas of the Kenya highlands the developmental period will prove to be between 15 and 20 days, and it will certainly be less at the Coast.

Whether there are definite periods of multiplication in this country is unknown, but it is of importance to determine the relative abundance at different times of the year in order to arrive at the best spraying programme.

Control

As the mite has only recently been found here and the first object of this note is to record this at an early date, no detailed work on control by sprays has yet been possible. But it has been possible to carry out some preliminary experiments with several spray materials at Lower Kabete. The petroleum oil locally available and commonly used for the control of scale insects has been shown to be fairly effective, though a considerable number of applications appear to be necessary to reduce a severe attack. Nicotine sulphate has been added to the oil and it is thought that

this increases the effectiveness of the spray though this point has not yet been experimentally proved. The spray is as follows:—

One pint white oil (two commercial oils available on the local market).

One fluid ounce nicotine sulphate 40 per cent.

Four gallons water.

Among sprays tried on infested trees for other purposes are Malathion and Diazinon. It seems clear from these sprayings that Malathion has no effect on the mite. This is not certain in the case of Diazinon but this material is not recommended for the purpose, and a better has been found. The best results have been obtained with the acaricide chlorobenzilate. This material at 0.1 per cent (4 c.c. per litre of a 25 per cent emulsifiable solution) has proved very effective. Trees almost completely "shut-up" by severe mite attack, have broken out into vigorous, healthy growth after one application. This occurred on all trees sprayed but a few shoots remained "stopped" and the kill was not complete. Unsprayed trees remained heavily infested during this period with many mites present in all infested buds. In further trials, Mr. Crowe, Entomologist at Kisumu, found similarly that sprayed trees put on new growth but examination showed living mites still present. He considered that a higher pressure than he applied with a hand sprayer would be required.

As a result of these preliminary trials it is safe to state that chlorobenzilate is highly toxic to the mite, and shows great promise that it might be developed into an effective control measure. To this end, further work to determine how many (or rather, how few) applications are necessary and also the lowest strength at which it is effective must be done. It may be effective at well under the strength of 0.1 per cent applied. This acaricide is stated to be of fairly low toxicity to man and no special precautions in the way of protective clothing are considered necessary in spraying the diluted material. Normal care with the concentrate should be taken, such as avoiding contact with the skin, and prompt washing if contact occurs. The emulsifiable solution mixes readily, spreads well and is easy to use.

Summary

The Citrus bud mite, *Aceria sheldoni* (Ewing), a major pest of citrus, was recently recognized in Kenya, and is now known to be widespread. It is responsible for the poor growth made by much of the citrus here.

The acaricide chlorobenzilate shows promise of being an effective control.

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THE BARK DISEASES OF COFFEE

By G. B. Wallace and Maud M. Wallace, Department of Agriculture, Tanganyika

(*Received for publication on* 10*th February,* 1955)

Two diseases have been described from the bark of coffee trees in East Africa. It is one purpose of this note to show the relationship of the Fusarium fungi which are associated with them.

The first of these diseases was named Coffee bark disease by Dr. H. H. Storey who discovered it in the Usambara Mountains of Tanganyika in 1930, and described it in detail in 1932.[1] A short, popular account of that disease was given in Tanganyika Department of Agriculture Mycological Leaflet No. 13, revised in 1933. The cause of the Bark disease was shown by Storey to be *Fusarium lateritium* var. *longum,* existing as two strains designated A1 and A2.

The Bark disease is now very prevalent and destructive in the coffee plantations of the Usambara Mountains. It is also present, although apparently quite mild, on Kilimanjaro and in the Uluguru Mountains. In coffee stem material received for examination from Nyasaland, the pathogen of Bark disease was isolated and identified.

The second disease in coffee bark was first observed by the late L. F. Higgens, Agricultural Assistant in the Tanganyika Department of Agriculture, at Kibongoto on Kilimanjaro in 1936. It was described in the *East African Agricultural Journal* by one of us (G.B.W.) in 1939.[2] It was at first considered to be non-parasitic, and was so described in the article. In 1953–1954, however, during an investigation into the causes of rots in coffeee stems and branches, the disease was found by one of us (M.M.W.) to be associated with a fungus. This was identified as *Fusarium stilboides* and that name was confirmed by courtesy of Dr. W. L. Gordon of Winnipeg, an authority on the genus. To distinguish this disease it has been named Scaly bark[3] based on its most common symptom.

The Scaly bark disease is becoming increasingly widespread and destructive in Tanganyika: on Kilimanjaro and in the Usambara and Uluguru Mountains. Data upon it are gradually emerging: it is an insidious disease, gradually affecting entire stems and branches of coffee trees. Its general mode of entry into the plant is not certain, but there is reason to believe that one important entry point is at pruning wounds. The first isolation of the fungus *F. stilboides* was from discoloured wood below a pruning cut. It is invariably obtained from the characteristic dark-coloured tissues below the scaly bark of stems and branches. Other fungi found occasionally are *Colletotrichum coffeanum, Verticillium* sp., *Trichoderma viride,* etc., but these have little importance. The disease has been seen in its most intense form in trees exposed to full sunshine. Further observations are required on the effects of environmental factors.

Early stages of the disease are not easily recognized; the distinct Scaly bark symptoms have so far been observed only in stems and branches of trees older than five years of age. This has significance in measures for control, mentioned below. The stem and branch symptoms are as described and illustrated in the *Journal* article.[2] It is now clear that the disease symptoms have, for a long time, been dismissed as those of old age or of unfavourable environment, etc. No symptoms have been observed in leaves or on cherries by the authors.

The disease is normally not fatal, and in the few cases found in dead or dying trees at the end of 1954, deaths may have been partly a result of abnormally dry conditions and of the "Punky heart" form of pruning-cut rot.

Identity of the Scaly Bark Fungus

When a Fusarium was found to be associated with Scaly bark, it was decided to compare it with the species known to cause Bark disease, *F. lateritium* var. *longum.* No culture of the latter had been maintained from the original isolations, but a culture was made from fresh Bark disease material collected above Lushoto; this was designated culture No. 400D of 1953. Its identity was confirmed by Dr. Gordon, and its pathogenicity was proved by inoculation into coffee stems, though the response was slow. Inoculated into the youngest internode of coffee laterals, it spread throughout the internode, causing the death and fall of the two end leaves and the bud, in one case after 43 days, in another after 70 days.

Isolations of *F. stilboides* from Kilimanjaro Scaly bark were also inoculated into growing

coffee twigs. The first inoculations were unsuccessful, but in a later attempt infection resulted, and at the time of writing the symptoms are following a very similar pattern to those brought about by *F. lateritium* var. *longum*. So far no reproduction of the Scaly bark symptoms seen in older trees has been obtained.

Inoculations with Fusarium isolations from both diseases were also carried out in the field, on young suckers emerging from multiple-stem trees. At the time of writing there has not been a sufficient interval to ascertain whether the inoculated suckers will be killed*, but it is clear that both isolations are producing similar disease symptoms. Control shoots stabbed with a sterile needle show no ill effects.

The question then arose as to the relationship of our Fusarium 400D and our *Fusarium stilboides*. Storey described two strains of his *F. lateritium* var. *longum*—A1 and A2, both of which he found to be pathogenic and implicated in the Bark disease. The growth of our isolation 400D on culture media is very close to that of Storey's description of his A2 in culture. The growth in culture of our *F. stilboides* agreed closely with Storey's description of his A1. Dr. Gordon has stated (*in litt.*) that he has no doubt our interpretations are correct.

To summarize, there is one fungus species *Fusarium lateritium* var. *longum* which exists in two forms A1 and A2. The A1 is also known as *Fusarium stilboides*. Both strains can cause Bark disease, but only the A1 can cause Scaly bark. From the practical point of view we are dealing with two diseases.

The correct determination of species of the genus Fusarium is always a difficulty. Variations in culture and mutations occur to make this so. Wollenweber's classification has been greatly simplified by Snyder and Hansen, and according to them, *F. stilboides* Wr. and *F. lateritium* Nees var. *longum* Wr. are regarded as synonyms of *F. lateritium* Nees emend. Snyder and Hansen. Dr. Gordon concurs in this arrangement.[4] *Fusarium lateritium* has a perfect (perithecial) stage known as *Gibberella baccata* (Wallr.) Sacc., but no perithecia were encountered either in nature or in culture during the course of this work.

For the record, the following notes on the growth of our *F. stilboides*, or *F. lateritium* strain A1 (Storey), are given: the surface of a slant of Czapek-Dox agar is fairly quickly covered with what is at first a flat white mycelial growth. After a few days a pink colour (Ridgway "Carmine") is produced at top and bottom of the culture. After about three weeks, the white central area is minutely tufted, and the colour of the extremities is "Acajou red" to "Vandyke red": with age this deepens to "Daphne red". Sometimes blue-green sclerotia are developed in the mycelium. In Storey's account of the growth of his strain A1, there is mention of a deep carmine colour, but he does not state if this is restricted to the top and bottom in tube cultures which is so characteristic a feature of our isolations.

Control

There seem at present to be better prospects of controlling Scaly bark than Bark disease. Suggested measures for control of the former are based on two observations: the first is that the uprights on multiple-stem trees appear to be very much less susceptible to infection than the older branches on single-stem trees. It may be that the fungus is so slow growing that it has not time to produce symptoms in the multiples before their cycle is completed and they are cut back. Support is lent to this view by the absence of symptoms in the main stems of trees under about five years old. With our present knowledge there is thus an apparent advantage in growing coffee on the multiple-stem system when Scaly bark is prevalent. Tests are planned at Lyamungu with a fungicide to be applied to the bases (the mother stems) of multiple-stem trees and on trees from one year old onwards, in an endeavour to protect them from infection.

The second observation is that the Scaly bark fungus is sometimes found under pruning cuts. There may be other means of entry, but at least the wounds made in pruning and stumping should be protected. The need for more attention to protection of pruning cuts has already been emphasized in Mycological Circular No. 32 of the Tanganyika Department of Agriculture, with the object of preventing the considerable amount of decay that commences at such wounds, and corresponding loss of crop. Trials are being undertaken with a number of paints, in order to find one satisfactory for coffee. Callusing of coffee wounds is so slow as to be quite ineffective, and a paint is required which will be durable and cheap, as well as effective in excluding rot organisms. A satisfactory paint would serve a double purpose: to prevent the entry of both rot and Scaly bark organisms.

* After 87 days one sucker which had been inoculated with *F. stilboides* was dead, and that species was re-isolated from it.

Further investigations on Scaly bark are required, to obtain information on other possible means of entry of the parasite; the conditions of infection, such as age of the trees or of particular tissues; the effects of shade and exposure, etc.

Control of Bark disease is more difficult. Since infection is most usual at the bases of new fast-growing shoots, particularly on stumped single-stemmed trees, it has been advised that cutting back be done in at least two stages. The object is to encourage slow-growing sturdy shoots rather than sappy shoots. Spraying young shoots whether on the stump of multiple-stem trees or at the top of single-stem trees would be expected to reduce the amount of infection. Where either disease occurs it would be advisable to remove and burn all prunings; this would destroy much of the local spore-bearing trash.

Scaly bark specimens may be seen at the Plant Pathology Laboratories and at the Agricultural Offices, Moshi and Arusha.

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PRELIMINARY TOBACCO EELWORM INVESTIGATIONS IN UGANDA

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At the instigation of the Uganda Department of Agriculture a survey of the incidence of the root-knot eelworm was made in the tobacco-growing areas of Uganda during 1952 and 1953. In early 1953 an experiment was laid down to discover to what extent the eelworm could be controlled by simple chemical methods and what increase in crop occurred by such control, and in 1954 an attempt was made to discover whether control was practicable on a field scale on tobacco grown by peasant farmers.

This account is a summary of work which will be described more fully in the "Record of Investigations" of the Department of Agriculture.

Survey

Prior to a paper by R. G. Chitwood[1] published in 1949, the root-knot nematodes were collectively known as *Heterodera marioni.* Chitwood's revision of the genus *Meloidogyne* has now been generally accepted and root-knot nematodes are considered to be of this genus of which there are a number of species. Without special training the separate species of *Meloidogyne* are very difficult to identify. Owing to this fact and the shortage of specialists available for identifying the species, the survey was carried out to discover the distribution and incidence of the genus *Meloidogyne.*

The root-knot eelworm is present throughout the tobacco-growing areas of Uganda (*see* map). It has been found in numerous other places and is probably widespread throughout the Protectorate.

The eelworm is not restricted to tobacco seedbeds, swamps or hills; at altitudes of over 5,500 ft. it is difficult to find and appears to be of no importance as a pest; at heights of over 7,000 ft. it was not found at all. In all other areas it was generally easy to find the eelworm on suitable host plants.

The conclusions drawn from this survey are that the infection of tobacco by the pest is extremely likely to occur regardless of the situation of the seedbeds but there is, as yet and in most cases, no obvious predisposing cause of a high infestation. A low infestation occurred on land which had previously carried a pure stand of *Hyparrhenia rufa* in parts of Acholi. Apparently pure stands of natural Elephant grass have, however, a high proportion of dicotyledonous weeds on which the eelworm was frequently discovered.

Chemical Control

The site of the experiment on chemical control was the Agricultural Department's farm at Bulindi in Bunyoro. The chemical used for soil fumigation was Shell D-D and was introduced to the required depth of 9 in. through funnels and tubing of copper. The injections were spaced at 12-in. intervals and the dosage of 6 c.c. per injection was introduced from measuring cylinders.

The seedbed area, on which four beds were treated and the remainder untreated, was of uncertain past history but was the one which would have been used under normal circumstances.

The variety of tobacco in the experiment was Heavy Western, planted out at a spacing of 3 ft. x 3 ft. and eventually fire-cured.

On the farm itself, where the tobacco was to be transplanted, five 4 x 4 Latin squares were marked out, each plot being 7 yards x 7 yards (49 plants) and each square therefore growing 784 plants. Two Latin squares were situated on land previously under natural Elephant grass for at least 14 years, two on land previously under a weedy ley of *Chloris gayana* for three years and one on land which had regenerated naturally for three years after a crop of tobacco.

The treatments applied to the tobacco grown in the Latin squares were:—

A_0 B_0 — Seedlings transplanted from untreated beds into sites not previously treated.

A_0 B_1 — Seedlings transplanted from untreated beds into sites treated with soil fumigant.

A_1 B — Seedlings transplanted from treated beds into sites not previously treated.

A_1 B_1 — Seedlings transplanted from treated beds into sites treated with soil fumigant.

The field site treatment consisted of three injections of 6 c.c. D-D at a depth of 9 in., 8 in. from the marked transplant site and equidistant from each other. Except for the treatments all cultural practices were the same as are normally carried out in Uganda.

Results

Seedbed Treatment.—Table I shows the estimate of the percentage of plants infested with eelworm in the treated and untreated seedbeds. Random samples were examined through a low-power binocular miscroscope.

TABLE I

	No. of Plants Examined	No. of Plants with Eelworm	Per Cent Attacked
Seedbeds treated ..	220	48	21·8%
Seedbeds untreated	300	224	74·7%

This is highly significant by an x^2 test.

Percentage Infestation by Eelworm at Harvest.—Table II is an estimation of the percentage infestation on plants at harvest, deduced by using a formula described by Smith and Taylor[2], in a combined analysis of the five Latin squares.

TABLE II

Treatment	Mean % Attack
A_0 B_0 ..	93·9
A_0 B_1 ..	86·3
A_1 B_0 ..	75·7
A_1 B_1 ..	65·2

L.S.D. of 2 means (P=0·05) : 5·1.

TABLE III.—INTERACTION

	A_0	A_1	Mean
B_0	93·9	75·7	84·8
B_1	86·3	65·2	75·7
Mean ..	90·1	70·4	80·3

L.S.D. of 2 means (P=0·05) : 3·6.

Both seedbed and field-site treatments show a significant reduction in percentage eelworm infestation at the 1 per cent level, but there is no interaction between them. (Table III.)

Yields.—Table IV is a combined analysis of the yields of the five Latin squares in pounds of green leaf per plot.

TABLE IV

Treatment	Mean lb. per Plot
A_0 B_0 ..	37·0
A_0 B_1 ..	45·0
A_1 B_0 ..	65·6
A_1 B_1 ..	64·7

L.S.D. of 2 means (P=0·05) : 8·0.

TABLE V.—INTERACTION

	A_0	A_1	Mean
B_0	37·0	65·6	51·6
B_1	45·0	64·7	54·9
Mean ..	41·0	65·2	53·1

L.S.D. of 2 means (P=0·05) : 5·7.

The seedbed treatment is highly significant but there is no interaction nor is the field-site treatment significant. (Table V.)

Yields of cured leaf obtained subsequently were rejected because losses from theft or other causes made them unreliable.

An analysis of the number of plants surviving to harvest showed that seedbed treatment had a significant effect in preventing losses during the growing season; the plots of seedbed-treated plants containing on an average approximately 10 per cent more plants than the controls. The field-site treatments did not significantly prevent losses in the field.

The yields per plant were also analysed and seedbed treatments produced an average yield increase of approximately 60 per cent. It would appear, therefore, that the overall increase in yield per plot was due more to the effect of the seedbed treatment producing larger plants than to the increase in stand resulting from such a treatment.

Conclusions.—D-D soil fumigant, as applied in this experiment, reduces the infestation of eelworm on seedlings when the seedbeds are treated and on tobacco plants at harvest when either the seedbeds, the field sites or both are treated. Under the conditions of the experiment the green leaf yield was increased by about 75 per cent when seedbeds were treated and this treatment also prevented a loss of stand through the growing season although this did not in fact contribute much to the increase in yield. The field-site treatments did not significantly affect the yield.

TREATMENT OF SEEDBEDS UNDER PEASANT SUPERVISION

With the results of the seedbed injection experiment at Bulindi available it was considered that the injection of seedbeds on a wider scale was justified. It was presumed that, with reasonable care and maintenance of the seedbeds, and if injections were correctly carried out, soil fumigation with D-D would be beneficial.

In January, 1954, the necessary instruments and soil fumigant were provided, with supervision, at seven different widely separated, seedbeds and injections were carried out by the individual growers.

MAIN TOBACCO-GROWING AREAS IN UGANDA

Since yields would be impossible to estimate the treated beds were examined during the end of March and beginning of April in order to see whether benefit from the treatment was obvious, as it was at Bulindi in 1953. Seedlings from treated beds at Bulindi were very noticeably larger and more sturdy than those from untreated beds; in addition, treated beds were free from gaps whilst untreated beds were very gappy. It was felt that unless such benefits from

seedbed injection were visible on native seedbeds, no benefit to the plants later in life could be presumed.

Conclusions.—It is not possible to state that soil injections as carried out on seven different seedbed sites were beneficial.

The general standard of seedbed care and maintenance was low. Failure to supply enough water to the developing seedbeds would particularly tend to mask any beneficial results from soil injection and, whereas under better conditions such benefit was obvious in the seedbeds, under the circumstances no such benefit was apparent and, therefore, no benefit to the plant later in life could be presumed.

Finally, from observing peasant farmers injecting seedbeds, it would appear that, although capable of satisfactory work under close supervision, generally speaking, unless such supervision is available, they are, at present, incapable of carrying out a satisfactory series of injections.

My thanks are due to Messrs. J. D. Jameson and W. R. Mills for their assistance in the statistical analyses and many other members of the Uganda Agricultural Department for their co-operation and help in other ways.

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RESISTANCE TO TAKE ALL DISEASE IN KENYA WHEAT 131

II—EFFECT ON YIELD

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In a previous paper[1] results were presented which showed that the wheat 131 was resistant though not immune to the Take all fungus, *Ophiobolus graminis*. An experiment has now been completed in which the actual effect of the fungus on the yield of 131 has been compared with its effect on a susceptible wheat. For this purpose Kenya Governor was used.

Experimental Lay-out

Three blocks were laid out, contained in wooden frames. They were divided into "disease" and "disease-free" plots. The appropriate plots were artificially and heavily infected with Take all. Half of each plot was planted with Kenya Governor and half with 131. These plots were 7 ft. 3 in. x 5 ft. 3 in. in size. After the first harvest, the plots were replanted at right-angles so as to minimize any residual varietal effect. Watering was necessary during the later stages of the second harvest.

Results

Striking results were obtained in the first harvest (Table I). However, because of the small number of replications, significance failed. Similar results were obtained in the second harvest (Table II). In this second harvest the 131 yields were significantly lower in proportion than those of Kenya Governor due purely to the seasonal effect (Tables IV and V). It is likely that Kenya Governor, being a much quicker growing wheat, made much of its growth before the cessation of the rains while 131 suffered more due to its being grown out of season. The total yields of the combined trials are shown in Table III. The analyses of results are presented in Tables IV and V using the combined yield figures taken over the two trials. The figures were analysed according to the method given by Paterson.[2]

TABLE I.—FIRST HARVEST—YIELDS IN GMS.

	Kenya Governor		131	
	Infected	Not Infected	Infected	Not Infected
Block I ..	43	238	340	350
Block II ..	110	234	365	630
Block III ..	150	230	615	450

TABLE II.—SECOND HARVEST—YIELDS IN GMS.

	Kenya Governor		131	
	Infected	Not Infected	Infected	Not Infected
Block I ..	70	130	143	175
Block II ..	115	152	141	139
Block III ..	84	197	193	155

TABLE III.—TOTAL YIELDS

	First Trial		Second Trial		Combined Yields	
	Infected	Not Infected	Infected	Not Infected	Infected	Not Infected
131 ..	1,320	1,430	477	469	1,797	1,899
K.G. ..	303	702	269	479	572	1,181

TABLE IV.—ANALYSIS OF 131 YIELDS

	S.S.	D.F.	Variance	F.
Blocks ..	312,121	5	—	—
Season ..	271,201	1	271,201	26·51*
Error (*a*) ..	40,920	4	10,230	—
Disease ..	867	1	867	Insignificant.
Interaction—(Disease × Season).	1,161	1	1,161	Insignificant.
Error (*b*) ..	47,983	4	11,996	—
TOTAL ..	362,132	11	—	—

*Significant at 1%.

TABLE V.—ANALYSIS OF KENYA GOVERNOR YIELDS

	S.S.	D.F.	Variance	F.
Blocks ..	9,890	5	—	—
Season ..	5,504	1	5,504	Insignificant.
Error (*a*) ..	4,386	4	1,097	—
Disease ..	30,907	1	30,907	25·31*
Interaction—(Disease × Season).	2,977	1	2,977	Insignificant.
Error (*b*) ..	4,885	4	1,221	—
Total ..	48,659	11	—	—

*Significant at 1%.

Conclusions

Under the same conditions of heavy Take all infection and over two growing seasons, wheat 131 showed no appreciable reduction in yield due to the disease while Kenya Governor, a susceptible wheat, was so heavily attacked that a 48.5 per cent reduction in yield occurred.

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REGENERATION OF CHLOROPHORA EXCELSA (MVULE) IN UGANDA IN RELATION TO SOIL-ROOT CONDITIONS

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The Mvule tree, *Chlorophora excelsa* (Welw.) Benth. & Hook. f., is one of the most important timber trees in Africa. Its distribution is extensive and corresponds more or less with the tropic zone. In Uganda it is widespread, being particularly abundant in the south-east (Busoga district and the south part of Mbale district) where it grows on land which has been largely denuded of the original forest or woodland, and is now a heavily cultivated false savannah. Both in Uganda and throughout tropical Africa attention has frequently been drawn to the poor regeneration of Mvule and little is known of its autecology. The present paper is the result of an investigation of features which it was thought might help or justify methods of regeneration of this species. The economic importance of the subject is shown by the virtual failure to regenerate Mvule artificially in Uganda. It was considered likely that a more detailed study of soils, root systems and seedlings in relation to regeneration might be profitable in supplying answers, in part at least, to such questions as choice of suitable soils, best spacing and pure versus mixed stands.

Soil Aspects

Tondeur[1] appears to have been the first to record the close association of the Mvule tree with well-cultivated land, and he stresses the importance to successful growth of the physical condition of the soil and absence of fire, browsing by animals, excessive shade, lianes and theft. With regard to chemical properties of the soil, it has long been known that the Mvule tree secretes stony calcium carbonate nodules in the trunk (Martin[2]). Martin[3] states, but does not give any quantitative data, that the tree needs a soil rich in calcium and this is the case in a typical Mvule district. Thomas[4] found by qualitative tests high base contents and alkalinity in soils under the Mvule canopy. Thomas ascribes this to former house sites, refuse pits or termite mounds. There appears little doubt that alkalinity and perhaps high base status favours the growth of Mvule as it grows far better in the most productive agricultural soils. Thomas cites examples of plantations in Lango district which are better than those of Busoga because their soils are more alkaline, and he states that in the Sesse Islands Mvule is found only on restricted areas of base-rich soil. Whether the alkalinity is the cause or the effect is the first point to clarify. This is attempted here by means of well replicated analytical data.

Soil samples were collected in Busoga from around five Mvule trees of various sizes on widely separated sites with different soil types, but all having a shrub or tall grass cover around the bole. Each sample was made up of four sub-samples taken on the axis of a cross at 10-ft. intervals from the bole beginning at 5 or 10 ft. and ending at 80 ft., beyond the extent of the crown. The analytical data for four trees are presented in Table I, the data for the fifth tree in Table II show the same trend but with different sample depths.

Table I—Plant Nutrient Status and Distance from Bole

Sites—

Namwiwa, Bulamogi County.
Lubolo, Bulamogi County.
Kitegalwa, 4 miles east of Navivumbi on road from Buwaya to Bugiri, Bugweri County.
Kitumbezi Estate, Navivumbi, Bugweri County.

0–3 Inches Depth

Distance (feet)	10	20	30	40	50	80	
pH	7·0	6·8	6·7	6·6	6·4	6·2	Mean of 4 sites
Ca me % ..	5·2	4·3	3·6	3·4	2·1	2·5	
Mg me % ..	2·8	2·4	2·0	1·7	1·3	1·0	
K me % ..	1·30	1·06	·87	·81	·55	·46	
TEB me %	9·3	8·8	6·5	5·9	4·0	4·0	
P_2O_5 p.p.m.	242	221	158	70	75	97	Mean of 3 sites
C % ..	1·45	1·27	1·09	1·12	·80	·70	
N % ..	·24	·21	·18	·18	·14	·12	
C/N ..	6·0	6·0	6·0	6·2	5·7	5·8	

9–12 Inches Depth

Distance (feet)	10	20	30	40	50	80	
pH	6·6	6·5	6·0	5·9	5·6	5·6	Mean of 3 sites
Ca me % ..	3·5	2·5	2·5	2·6	2·4	2·3	
Mg me % ..	1·7	1·3	1·3	1·4	1·5	1·1	
K me % ..	·73	·57	·50	·45	·30	·29	
TEB me %	5·9	4·4	4·3	4·5	4·2	3·7	
P_2O_5 p.p.m.	40	58	33	18	39	46	
C % ..	·65	·58	·56	·58	·53	·47	

Methods—

pH by glass electrode method.
Bases by Lundegardh spectrographic method.
TEB = Total Exchangeable Bases = Ca + Mg + K.
P_2O_5 by Truog method.
C by Walkley and Black method.
N by macro-Kjeldahl method.

Table II.—Plant Nutients and Soil Depth

Site:—Bugonzo two miles west of Kaliro, Bulamogi county.

Distance (feet)	Depth (in.)	pH	Milli-Equivalents per 100 gms.					% C
			Ca	Mg	K	Mn	TEB	
5	0–6	7·1	8·0	3·3	2·08	·03	13·4	1·46
5	6–12	6·6	4·9	2·1	1·77	·01	8·8	1·14
10	0–6	6·6	4·1	1·4	1·15	·05	6·7	1·37
10	6–12	5·3	2·5	1·0	1·02	·03	4·6	1·14
10	12–18	5·1	2·2	·6	·61	·05	3·5	·83
20	0–6	6·3	6·4	1·4	·94	·03	8·8	1·49
20	6–12	6·9	12·0	·6	·56	·02	13·2	1·16
20	12–18	7·3	11·7	1·4	·53	·02	13·7	1·16
30	0–6	6·1	5·2	1·4	·81	·06	7·5	1·34
30	6–12	5·5	3·5	·8	·36	·05	4·7	·99
30	12–18	5·4	3·0	·8	·26	·04	4·1	·81
60	0–6	5·6	3·3	1·4	·53	·08	5·31	1·28
60	6–12	5·2	2·3	1·4	·53	·04	4·27	·92
60	12–18	5·2	1·7	·8	·30	·05	2·85	·75

It is abundantly clear that there is a considerable build-up of alkalinity and base status near the boles (confirming Thomas[4]), and that this is most marked in the top three inches and first 10 ft. away. As would be expected, the contents of all bases are closely correlated with organic matter. The source of this organic matter and bases cannot be pinpointed with certainty but it is evidently derived from the falling leaves, the vegetation round the trees, possible kraaling or sheltering of animals and perhaps human beings round the bole, and honeydew drip.

It is relevant now to assess the contribution of each of these factors. No evidence of habitation was found by the five trees and house sites and refuse pits are precluded as their soil reactions and base status are usually much higher throughout the profile. Fallen Mvule leaves on analysis gave the surprisingly low calcium figure of 2.3 per cent on the oven-dry basis which is less than half the accepted figure of 5 per cent estimated by Vinogradov[5] for terrestrial plants. Magnesium was only 0.39 per cent and potassium only 0.77 per cent compared with an average 0.7 per cent and 3.0 per cent respectively for terrestrial plants. Mvule leaves are quite large (6 × 3 in.) and strong winds would tend to blow them well away from the area under the canopy of the tree. On cleared land, from very tall trees, they have been seen as far as 300 ft. from the bole. Thus, despite a natural tendency for leaves to fall directly under the crown, and especially its densest parts above or near the bole, the contribution of fallen leaves to the build up of high nutrient status must not be overrated.

On the other hand vegetation under a Mvule tree is often denser than on surrounding open sites, perhaps related to the shade, higher humidity and slight fire protection, and the build-up of humus and bases by a tall grass and shrub cover near the bole would be considerable. The shade under Mvule is often too dense for the cultivation of crops and even if the area under the canopy were cultivated, this would be discontinuous and likely to be least nearest the bole. Elephant grass (*Pennisetum purpureum* Schum.) roots extend to at least 20 ft. depth and mine the soil for bases, and over the tree's lifetime the residues from roots and tops would be sufficient to build up a rich surface soil. The most widespread agricultural soils in Uganda owe their fertility to Elephant and other tall grasses and not to inherently rich soil parent material (*see* example at Nakabango, Busoga, in Table III). Elephant grass roots may be of benefit to the growing tree in providing, when they die, channels for the tree roots in an otherwise rather compacted subsoil. Competition for water between grass and tree might sometimes be severe, but owing to the obvious success of this association in Busoga the balance there is in favour of the Mvule tree.

Returning to Table I, prolonged cultivation of the land beyond 30 ft. from the trunk probably accounts for the low nutrient figures found at these distances.

The effects of cattle on soil fertility are too well known for further comments.

The Mvule tree while in flower (about five weeks' duration) drips large amounts of honeydew. This was considered as a possible contributor to the soil alkalinity; however, a

sample of honeydew on analysis only gave 27 p.p.m. calcium, which would hardly affect the soil.

Rainwater flowing down a large trunk and dripping off branches would certainly dissolve out bases especially if calcium carbonate nodules were present. Cuts in the bark and wounds would also contribute bases to the soil as Mvule sap contains up to 0.73 per cent calcium.

Termite mounds are often more alkaline and richer in bases than the surrounding soil and Thomas[4] states that they are almost invariably associated with Mvule trees. This phenomenon, in Busoga at least, we have not fully confirmed and it is more likely that the termites are attracted to the tree, perhaps by the higher alkalinity already present, and subsequently build their mounds.

With regard to the physical properties of soils on which Mvule trees grow, Templer[6 and 7] remarks that the lack of surface compaction in agricultural cultivations greatly improves aeration which is vitally important to the strongly lenticelled root system. According to Dawkins[8] depth and humification of the soil and the state of vegetation on it are useful indicators as to its suitability. To this may be added that Mvule will only grow on free-draining sites. Such sites are afforded over a large area of southern Uganda on soils of the Earthy Red Latosol world group. They are usually deep, friable, red clays with a humose, somewhat lighter, topsoil. These soils are already well supplied with bases for the early needs of the young trees. Once they become established, further build-up of alkalinity and nutrient bases takes place but this is only incidental to the growth of the tree as it is superficial and confined to the area of least root volume, as will now be described.

Root System of the Mvule Tree

In order to obtain a picture of the normal root distribution in deep soil two trenches were dug across the root systems of two isolated Mvule trees at Kimaka, four miles north of Jinja, Busoga. Across the small tree the trench was 6 ft. deep and 30 ft. long; across the larger tree it was 10 ft. deep and 22 ft. long (half section).

Both trenches were dug in a soil 18 ft. deep on level ground overlying amphibolite of the Karagwe-Ankolean series. The soil is a red loam of good physical structure almost completely uniform throughout its entire depth and the analytical data at Nakabango, Busoga, in Table III would be similar to this site. Such a soil is exceptionally deep for this part of Uganda and one of the most fertile in the Protectorate. It may be assumed that such conditions should be ideal for tree growth, and that the root form shown by Mvule here should be typical of the kind formed on any moderately deep and fertile soil. The root systems of the two trees is shown in tabular form.

Despite their difference in size both trees examined had a similar root distribution. There was no taproot, but directly below the trunk were a number of vertically descending roots which divided near ground level. From this knot of roots arose a number of large, obliquely descending heart roots and a few moderate sized, rapidly branching roots near the ground surface. Feeding roots (counted as those less than $\frac{1}{8}$-in. diameter) were well distributed in the profile but were not concentrated near the soil surface, and there were few in the immediate vicinity of the trunk. No feeding roots were seen in the profile at a distance about twice the spread of the crown in any direction and there seemed to be no particular level for the dying out of the feeding roots. From these observations it seems that exploitation of a deep profile by the root system is sparse but even, and extends to depths of at least 10 ft.

The greater part of the *Chlorophora* woodland belt in Busoga consists of deep and shallow soils derived from granite. Analytical data for deep and shallow profiles of soils derived from granite in typical *Chlorophora* woodland (cultivated) at Kaliro and Bulopa, Busoga, are also submitted in Table III. Both have about the same base contents in their topsoils but as all the subsoils are invariably base-deficient, the shallow soil would be hard put to supply the mineral nutrients of a large Mvule tree and particularly its water requirements in the young stage.

On shallow soils over the continuous ironstone (laterite) pavements which are abundant throughout the north of Busoga, rooting space is restricted and the form of the root system modified. Profiles exposed by wind-thrown Mvule trees on such soils showed a solid ironstone pan within 3 ft. of the ground surface, through which no large roots had been able to penetrate. The root system consisted entirely of surface roots spreading up to three times the radius of the crown. The largest roots were

ROOT SYSTEM OF TREE 1*

Girth over bark at breast height: 2 feet 10 inches.
Clear bole: 15 feet.
Total height: 35 feet.

Distance from bole (ft.)	15	13	11	9	7	5	3	1	Bole	1	3	5	7	9	11	15
Depth (inches) 0	Nil	5	2	2	Nil	Nil	3	6″–9″		4	3	Nil	Nil	Nil	Nil	
12	3	3	3	2	3	3	1 15″–x	8 18″–6″ 18″–9″		6 18″–x	2	3 27″–x 30″–x 30″–x	Nil	Nil	1	
36	Nil	Nil 39″–2″	3 48″–x	1	Nil	Nil 42″–x 42″–2″ 42″–4″	45″–x	Nil 42″–x 42″–x 42″–x		Nil 39″–10″	2 45″–x 51″–x	1	2 45″–x 45″–x	Nil 48″–x	Nil 39″–x 45″–x	
72																

ROOT SYSTEM OF TREE 2*
(*Half Section*)

Girth over bark at breast height: 8 feet 11½ inches.
Clear bole: 24 feet.
Total height: 70 feet.

Distance from bole (feet)	15	13	11	9	7	5	3	1	Bole
Depth (inches) 0									
Nil	3	2	1	2 8″–10″	12 12″–1½″	15 6″–x 9″–2″ 12″–x 12″–x	3		9″–15″
12									
3	4 24″–x 24″–x 24″–x	6	4	12 27″–x 27″–x 27″–x 27″–x	10 27″–5″	7 15″ 1½″ 18″–6″ 24″–8″	10 24″–1½″ 24″–1½″ 36″–x		21″–9″ 30″–12″
36									
5	7 48″–x 48″–x	6	6	5	10	10	15 57″–x 69″–x		6 42″–x 42″–x 42″–x 42″–x 42″–4″ 42″–6″
120									

* In each rectangle are shown the numbers of roots of various sizes in the equivalent soil section. The top figure is the number of roots of ⅛-inch diameter or less counted throughout the section; if there were no roots of this size, "nil" is shown. The lower figures show the depth of larger roots followed by x (between ⅛-inch and 1-inch diameter), or diameter specified. The number of roots less than ⅛-inch diameter includes those bunched together. In the top 9 inches there were many feeding roots under both trees, but few were Mvule.

TABLE III

Deep Soil derived from amphibolite. Nakabango, Busoga.
Vegetation: Dense sward of Elephant grass, at least ten years old.

Depth (Inches)	pH	MILLI-EQUIVALENTS PER 100 GMS.					p.p.m. P_2O_5	% C	% N	C/N
		Ca	Mg	K	Mn	TEB				
0–6 ..	6·2	11·7	8·1	2·56	·02	22·4	54	4·62	·38	12·1
6–9 ..	5·6	7·6	5·0	·91	·03	13·5	23	2·15	·21	10·2
9–18 ..	5·4	4·7	3·2	·33	·02	7·7	23	·78	·12	6·5
18–24 ..	5·4	4·2	3·0	·19	·02	7·4	25	·71	·10	7·1
24–36 ..	5·5	2·8	1·5	·16	·02	4·5	37	·33	·06	5·5
36–48 ..	5·6	2·9	1·5	·16	·02	4·6	25	·29	·05	5·8
48–60 ..	5·2	2·7	0·6	·17	·02	3·5	13	·21	·04	5·3
60–72 ..	5·2	2·9	1·1	·16	·07	4·2	22	·18	·04	4·9
72–80 ..	5·3	2·9	1·0	·16	·02	3·7	15	·15	·03	4·7
Mean data for seven sites under tree plantations. Same soil type as above.										
0–3 ..	6·5	7·4	5·0	1·41	·11	13·9	130	4·14	·46	9·1
Deep soil derived from granite. Kaliro, Busoga.										
Vegetation: Cultivated patch in *Chlorophora* woodland.										
0–3 ..	4·4	6·0	2·4	1·60	·13	10·1	128	1·31	·173	7·6
8–12 ..	5·0	12·5	1·5	·30	·16	14·5	57	1·29	·182	7·1
36–39 ..	5·0	1·5	·3	·67	·07	2·5	30	·56	·079	7·1
60	5·2	1·7	·3	·61	·05	2·7	40	·42	·06	7·0
96–102 ..	5·0	0·4	·3	·30	·02	1·0	42	·23	·035	6·5
168	5·0	1·7	·9	·29	·03	2·9	35	·18	·029	6·2
Shallow soil derived from granite. Bulopa, Busoga.										
Vegetation: Cultivated patch in *Chlorophora* woodland.										
0–6 ..	5·4	6·0	1·8	·28	·02	8·1	27	1·83	·23	8·0
6–12 ..	5·3	4·6	1·3	·16	·02	6·1	18	1·61	·18	8·9
12–19 ..	4·7	2·0	·6	·16	·02	2·8	23	1·04	·13	8·0
19–33 ..	5·1	·8	·6	·16	·02	1·6	11	·63	·09	7·0
33–36 ..	5·1	1·4	·6	·19	·02	2·2	23	·83	·11	7·6
*Deep forest soils of Sesse Islands (Masaka District, Uganda) in which Mvule is absent. (Mean of eight sites)										
0–6 ..	4·1	1·0	<·6	1·21	tr.	c. 2·5	587	2·80	·39	7·2

*Note high NPK and low Ca, Mg and pH.

less than 1-ft. diameter, small for the size of the trees. In all cases severing the root system (possibly helped by injury during the cultivation of plots which surrounded the trees) had stimulated the larger roots to produce sucker shoots where they ran close to the surface up to 50 ft. from the trunk.

It is clear that on shallow soils the root spread of Mvule is wider than normal, but it has not been discovered whether lack of root room has promoted greater exploitation by feeding roots in the available soil. Ironstone pans are frequently underlain by several feet of subsoil and if the pan is discontinuous rooting is scarcely restricted. Thus soil depth, and the impedance of rooting by ironstone pans, must be considered if Mvule is to be grown as a plantation tree.

SEEDLINGS IN RELATION TO SOIL AND LIGHT

The effects of variation in soil type and light intensity were studied in relation to seed germination.

Soil samples (surface 6 in.) were taken from under seven large female Mvule trees growing in a variety of vegetation types in east Busoga and the south part of Mbale. The sites were chosen for their variety in shade and soils and

occurred in anything from grassland to dense forest. All the sites were visited in May, 1951, when proximity to the parent tree and condition of natural regeneration from the seed of 1951 and previous years were recorded. The soils were dried, transported to Oxford, England, and placed in pots in which 30 seeds of Mvule were sown under a light soil covering in one set, and 30 seeds on the surface in another set. At the same time two sets of pots filled with sterilized sand were placed under six different light intensities and sown with 30 seeds. All the seed used was collected in April, 1951, from one Mvule tree in Busoga. Both soil and sand cultures were watered with tap water only. Germination and condition were recorded.

Germination occurred almost equally well respectively in and on soil from all seven sites. Buried seed was slower to germinate and produced slightly fewer seedlings than unburied seed, although it is normal in nursery practice in Uganda to bury seed lightly. Physical conditions of the soil were important; thus radicle penetration was poor on a soil from swamp forest, probably due to the high clay content, while radicle penetration was best on an undisturbed forest soil which retained good crumb structure. The sand cultures confirmed that germination of buried seed was slower. Light intensity did not affect the germination per cent but the less light the more serious was etiolation.

The above findings are as might be expected. Given sufficient moisture seedlings will thrive on cotyledonary reserves up to the "cotyledon stage" whatever the light intensity; thereafter it appears that those in darkness will not produce their first leaves. All stages are sensitive to drought. The poor germination of buried seed could not be explained. These results tie up well with field observations since seedlings from 1951 seed older than the first few leaves stage were only seen in cultivations where there was a fairly high light intensity. In open conditions it is agreed with Dawkins[8] that moisture is probably limiting but it cannot be admitted that more than a moderate amount of shade can be tolerated in the first season. There is no doubt that the high isolation, drip and splash described by Dawkins destroy a great number of seedlings in the open, where survival to the few leaves stage is common as compared to the heavy shade of forest and thicket, where it is believed the germination stage is seldom passed. Light shading is the rule in nurseries in Uganda, where it is relatively easy to raise plants.

Dawkins also states that Mvule seedlings will not tolerate continuously wet soils during the first few months of growth but that conditions must be sub-humid. When seeds were germinated at Oxford, England, under carefully simulated tropical conditions both in natural soils and sterilized sand cultures fed by balanced nutrient solutions, all the plants died of damping-off at or before the first leaf stage. It is possible that similar large-scale mortality occurs naturally, though it has not been observed; it would be favoured by the large numbers of seedlings crowded directly under parent trees, and by the greater humidity and shade in forest as compared to Mvule growing in open conditions.

In grassland without fire protection virtually all seedlings are destroyed by annual or more frequent fires; silviculturally complete fire protection, automatically provided by cultivation, is the only cure. Fire causes severe damage to trees of all ages; long strips of bark may be burnt off and the crown partly burnt, leaving it unbalanced and stunted. On the other hand good form can be attained by Mvule growing in open grassland if fire protected, though it is not always at all certain whether such trees have not grown up in thickets. But the crown of the open grown tree is normally large and unbalanced and the bole short compared with the forest or scrub grown tree.

Natural Regeneration

Successful natural regeneration is almost confined to partially or completely fire protected sites with high light intensity, such as medium height grassland, and current or recent cultivations, not necessarily on old house or refuse sites. Though Mvule trees of all ages are frequently seen growing on or near termite mounds, it is not certain that the mounds have not appeared subsequently to tree establishment. Seedlings have not been seen on the hard, exposed and often dry surfaces of termite mounds, which would appear to offer poor conditions for germination and early growth. However, termite mounds induce a fire-protected margin which favours establishment, and this factor is as likely to assist regeneration on termite mounds as slightly higher base content.

It was seen that there is abundant germination under the parent tree on bare ground in current or recently abandoned cultivations.

Even with light shade from scattered bushes or grass, survival to the first leaf stage is much less, and in forest only germination stages were seen. This is probably the main reason for the comparative absence of Mvule in forest. Owing to the nature of fruit of Mvule (an elongated syncarp which falls to the ground retaining most of the ripe achenes), much of the seed is bound to germinate under the parent tree, where, as recorded earlier, the soil is almost certain to be more fertile than surrounding soils if the tree is growing in grassland or light scrub. There is little doubt, as stated by Aubreville,[9] that birds and, according to Dawkins,* bats also, have a liking for the pulpy fruits; whether better germination and early establishment occur as a result of seed passing through the alimentary tracts of birds and bats is unknown, but the dispersive capacity of the seed is greatly increased. In Busoga isolated seedlings and saplings of Mvule can frequently be found far from any parent tree, whither they have been carried by chance by animals or birds. It seems that in the overall distribution of the species that physical factors like bad aeration and lack of friability (e.g. absence of Mvule in swamps) restrict establishment rather than base poverty.

Mvule coppices and suckers freely. Coppice shoots can only be produced artificially by wounding or felling the bole and so many coppice shoots may be produced on one stump that all are weakened by self-suppression. On the other hand suckers are a more satisfactory way of natural regeneration since they are spread out. Suckering can be stimulated by felling but also occurs naturally, and there is evidence that suckering is commonest on shallow soils. One example at Namwiwa, Busoga, had produced 17 stems up to 6 ft. girth at breast height in an area of only 40 sq. ft. round one stump. All stems were healthy except for smaller ones showing signs of suppression. The result was a dense pure stand of Mvule which should produce several large timber trees. This example of suckering on a shallow soil showed that under certain conditions Mvule can grow pure at very close spacings. Experiments with trenching and burning have not so far been able to repeat this dense sucker regeneration; the above case may have been an exception, and it is unknown what stimulation the stump received, if any. Despite lack of success so far, artificial stimulation by suckering offers a promising means of regeneration. Brasnett[10] objects to planting Mvule pure on the grounds that its deciduous habit promotes grass growth, and there is little doubt that in the absence of cultivation fire must be either rigidly excluded or the hazard made less by inducing an ever green understory or light grass cover.

Present evidence points to the desirability of attempting to grow Mvule at close spacings on soils that have at least 6 ft. of root room. Wider plantings in conjunction with agricultural crops should also be encouraged. Young Teak in Trinidad is invariably planted with food crops during the first year and it is standard practice there to establish orchard crops such as cocoa and citrus under the shade of tall food crops. Planting Mvule in lines or groups among bananas has proved successful in Kenya (Templer[6] and [7]) and such a *taungya* system should be tried in southern Uganda, preferably in conjunction with the native *shamba* system. That Mvule is associated with base richness in surface soil is a good reason for the encouragement of its regeneration (whether to produce timber or not) in cultivation; base richness and physical factors including shade and higher humidity under Mvule crowns are undoubtedly favourable to some crops.

Summary

(1) A comparison of base content of surface soils was made at varying distances up to 50 ft. from the boles of five mature Mvule trees. These showed that there is invariably a higher alkalinity and base content under large Mvule trees.

(2) The root system of Mvule is extensive on a deep soil with an even, sparse expliotation by feeding roots at all levels. On shallow soils the roots may extend up to three times the radius of the crown and are greatly restricted by ironstone pans.

(3) Germination tests with Mvule seeds showed that the nature of the substrate was unimportant but that burying seed appeared to slow germination and reduce germinative capacity. Under artificially simulated tropical conditions at Oxford, England, all seedlings rapidly damped off whether raised in natural soils or in sterilized sand cultures fed by balanced nutrient solutions.

(4) Natural regeneration is closely controlled by physical conditions. In the germination stage moisture is generally limiting and after the first few leaves stage light is limiting until the crown becomes free. In all stages fire is vital, and browsing and gall may be serious at sapling heights. Soil factors are seldom limiting except for the restriction of Mvule to freely draining soils with moderate to high base content.

(5) It is submitted that the best way of growing Mvule is on the deepest and most fertile soils with a

* Private communication.

reaction above pH5.0, and cultivation in the early stages. There appears to be no objection to pure crops of Mvule on silvicultural grounds, though it is unlikely that bole form and size in savannah can be as good as trees growing in mixture in natural high forest. Spacing trials are badly needed.

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SUDDEN DEATH DISEASE OF CASHEW TREES IN TANGANYIKA—A PRELIMINARY NOTE

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The purpose of this note is to record the presence, in the Southern Province of Tanganyika, of a disease of cashew nut trees (*Anacardium occidentale*) which is very similar to, and probably identical with the "sudden death" of cloves in Zanzibar. The latter disease was most recently studied by the Clove Research team of the East African Agriculture and Forestry Research Organization, and described by Nutman and Roberts.[2] They found the disease to be caused by a fungus which they named *Valsa eugeniæ*.[1] Since, in the case of the cashew disease, it has not been possible to undertake experiments to produce the condition artificially, using the fungus isolated, this note must be in the nature of a preliminary one. The subject is considered to be of sufficient interest and importance to merit the publication of the data so far collected.

The disease was first observed by the manager of a sisal plantation on his estate near Lindi in 1951, when about 10 trees died and were felled. In 1952, 20 to 30 trees were affected on an area almost adjacent to the first. These were stumped. In 1953 over a 100 trees were attacked and died. The disease was brought to the attention of the laboratory by the Agricultural Officer, Lindi, in September, 1953.

Trees attacked by this disease show a yellowing and then a russetting of the leaves—as if scorched by fire—and this takes place rapidly, in a matter of 10 days or a fortnight. This symptom was suggestive of the clove disease, and the relationship was strengthened by the isolation in culture from the main root of one tree, of a fungus which was recognized as being very closely allied to the conidial stage of *Valsa eugeniæ*. The cashew isolate was identified by Mr. E. W. Mason of the Commonwealth Mycological Institute as *Cytonæma* sp. which he later found to be indistinguishable from *Valsa eugeniæ* (conidial stage). *Cytonæma* sp. was again isolated, from another diseased tree, and it was found to grow out from pieces of cashew stems and roots which were held in a damp chamber for five or more weeks. The pycnidia appeared in enormous numbers on the cut surfaces of the wood and on the outer surface of the bark. When ripe the spores exuded from the ostioles in characteristic yellow cirri. Finally, after more than two months, a perithecial stage developed on some of the pieces. Mr. Mason, on receiving specimens of the latter, reported as follows: "I am unable to say that your fungus is not *Valsa eugeniæ*, as the perithecia, pycnidia and cultural characters of both appear the same".

During the course of the investigations, another fungus—*Botryodiplodia theobromæ*—was frequently isolated in culture and also appeared on the cashew chips held in damp chambers. This is probably only of secondary importance.

It should be added, as a further resemblance to the clove disease, that there is in the affected cashew trees a certain amount of yellow discolouration which is apparently invariably associated with diseased trees, and it was from such discoloured areas that the isolations were made. Further, those chips of cashew wood which developed the Cytonæma pycnidia all showed yellow colour, as did the roots.

There is thus a disease of cashew trees in southern Tanganyika having most of the symtoms of Sudden death of cloves, and with this disease is associated a fungus which is indistinguishable from *Valsa eugeniæ*. For these reasons it is proposed that the cashew disease be also termed Sudden death.

Control measures.—Control is not likely to be easy. Any measures would require to be applied to the known hosts of the parasite—at present clove and cashew. These trees belong to such diverse families, Myrtaceæ and Anacardiaceæ, that it will not be surprising if hosts in other families exist, and disease of this type should be watched for. Since it has been shown that the fungus can produce spore-bearing organs on the outside of the bark of stems, it would be a precaution if diseased trees were destroyed by burning.

Nutman and Roberts did not anticipate early results in the control of the disease in clove, but the progress of the investigations in Zanzibar will be watched with interest by cashew growers. Sudden death of clove has

now been recorded in Malaya (E. W. Mason *in litt.*), so there is a wider field of investigators of the problem.

We should like to acknowledge our indebtedness to the following: Mr. D. V. Chambers, Agricultural Officer, Lindi, who sent the first specimens and described the symptoms; Mr. J. B. Clegg and Mr. W. H. Andrews who, following Mr. Chambers, continued to send specimens; Messrs. the Lindi Sisal Estate, also for specimens. Finally we are grateful to Mr. E. W. Mason of the C.M.I., for his determinations of the specimens and cultures.

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COMMONWEALTH AGRICULTURE

The continuation after 1951 of the post-war rise in agricultural production in Commonwealth countries is analysed in *Commonwealth Agriculture,* published by the Commonwealth Economic Committee.* Among other causes the generally favourable weather of recent years was reflected in high yields but by the end of 1953 seasonal factors had checked the expansion in some cases. However, over the post-war years as a whole, production in many Commonwealth countries had risen more rapidly than that of the rest of the world. Progress was not uniform: several records were made, notably in rubber, wool and groundnuts, and all cereals, sugar, cotton, sisal, cheese and meat shared in the increase, but output of copra and butter fell in 1953 and the jute crop was halved. The heavy reductions in price after the peaks reached in 1951 by a number of commodities particularly affected by the Korean boom were, for the most part, reversed in 1953 or 1954, when the prices of tropical products in particular were much higher than before the war. Although with increasing population, consumption has grown in producing countries, the increase in production was, on the whole, enough to support increased exports and many records were established in 1952 or 1953 for both raw materials and foodstuffs. The position of the United Kingdom as the principal market for many agricultural products was strengthened, for the post-war rise in exports to some other markets, including the United States, suffered a check. Related to these developments was the continued increase in both output and consumption of fertilizers and in the production and use of agricultural machinery throughout the Commonwealth, although there has been some slackening of the pace in the United Kingdom and Canada in recent years.

The overall picture in Commonwealth countries since the war has been one of progress but it has been marked by differences between countries and, in some cases, temporary declines of two or three years' duration. Indices of agricultural production show that by and large the progress of Commonwealth countries compared well with that of Continental Europe and of the free world as a whole. Compared with before the war, output in the United Kingdom and Canada rose by more than half, while in Southern Rhodesia it increased nearly threefold. In India, where for some years production had been below the pre-war level, a recent substantial increase has occurred. For many commodities which figure largely in Commonwealth production and trade, output in recent years has reached levels strikingly higher than those ruling immediately before the war. Indeed, the only notable exceptions were tobacco, which was well below the pre-war level, and butter which had not quite made up the ground lost during the war. Production records were set up by several commodities, among which were wheat at 36 million tons, rice at 37 million tons, other grains (oats, barley and maize) at 31 million tons, sugar at 8 million tons, meat at 4.6 million tons, cheese at nearly 6 million cwt., rubber at 920 thousand tons, and wool at 2.2 thousand million lb. The post-war tendency for Commonwealth output to achieve a higher proportion of world output than before the war was maintained in recent years, particularly for grains and some tropical products: the proportion remained much the same as pre-war for groundnuts, copra and cheese but for rubber and cotton it was lower.

As in the case of production, for many Commonwealth countries the exports of major

* *Commonwealth Agriculture*—price 2*s.* 6*d.* net (2*s.* 9*d.*, post free), obtainable from H. M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

agricultural products reached record figures in recent years. In 1952 wheat and tobacco from Canada, dairy produce from New Zealand, and in 1951 coffee from Uganda and tobacco from India reached heights never before attained and, although lower in the following year, remained at very high levels. In 1953 cotton from Pakistan, tea from Ceylon, fresh fruit from South Africa, Australia and Nigeria, canned fruit from Australia, sugar from Australia and the British West Indies, sisal from Tanganyika and vegetable oils and oilseeds from Nigeria showed further increases to establish new records. Although some commodities declined from the peaks of earlier years and a few, including rubber from Malaya and Ceylon and meat from Canada, reached relatively low levels, expanded trade in agricultural products has been a feature of recent years throughout the Commonwealth. The United Kingdom is the world's largest importer of agricultural products, particularly of foodstuffs, and the most important market for Commonwealth countries which have increased their share of the total supplied to the United Kingdom from about 50 per cent before the war to nearly 60 per cent. However, the relative importance of the United Kingdom as an agricultural market declined somewhat, for in many cases total exports from Commonwealth countries increased proportionately more than did the share exported to the United Kingdom. The two other principal markets, the United States and Western Europe, are mostly concerned with industrial raw materials rather than with foodstuffs, for which they are largely self-sufficient. The proportion marketed in the United States, while in most cases well above pre-war, fell off after 1951 and the United States was no longer the largest single agricultural market for any Commonwealth country. Western Europe has become a more important market since the war for most Commonwealth countries: although the area requires mainly raw materials, it provides an important outlet for certain foodstuffs, for example Canadian grains and flour and East African coffee.

The course of world demand during the period under review has been reflected in two distinct price patterns. Prices of livestock products and, in the earlier part of the period, cereals tended in the main to continue to increase by moderate stages to levels substantially higher than before the war. On the other hand, the heavy price declines which followed the Korean boom in a number of raw materials were succeeded by a measure of stability or recovery in 1953 and 1954 and, on the whole, prices of raw materials and some tropical food products, when compared with pre-war, remained relatively more advanced than did those of the staple foods. For example, in 1953 export prices of Australian wool and of Indian cotton, which at the height of the boom had averaged more than twelve times the pre-war levels, were respectively about eight and five times as high as before the war, while New Zealand lamb was about twice as high and dairy products from Australia and New Zealand ranged between two-and-a-half and three-and-a-half times as high. The export price of wheat has fluctuated in recent years, reflecting the balance between the pressure of several ample harvests and intermittent heavy demand.

Production of agricultural machinery in Commonwealth countries has risen far above pre-war levels; while the United Kingdom and Canada are responsible for much the greater part of the total output, there is a substantial industry in Australia and a smaller, more specialized one, in New Zealand. The value of Commonwealth exports, almost entirely from the United Kingdom and Canada, rose from £3 million before the war to nearly £90 million in 1953. Commonwealth imports in the same year were valued at £125 million, mainly because of the large imports of tractors into Canada from the United States. Fertilizer output has fluctuated widely in recent years but has remained very much higher than before the war and, on the whole, the latest available figures indicate that earlier declines have been made good. Although the acute scarcity of elemental sulphur was ameliorated, development of the use of alternative materials was continued in order to safeguard the necessary expansion of the superphosphate industry. The wartime and post-war increase in the use of fertilizers in Commonwealth countries has continued in recent years; Commonwealth consumption of all plant foods in 1953 was about two-and-a-half times as large as before the war.

THE FECUNDITY OF TILAPIA SPECIES

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Fecundity may be defined for the purposes of this paper as the number of young produced during the lifetime of an individual; this number is determined by many factors, among which the more important are, the length of the breeding seasons, the frequency of spawning during a breeding season, the number of eggs laid at a spawning, and the care taken of the eggs before and after hatching.

Under favourable and uniform conditions *Tilapia* may spawn at frequent intervals throughout their reproductive life, but where there are marked seasonal changes in climate they may have a brief and well-defined annual breeding season. The number of spawnings a year is determined by two variables: the duration of the breeding seasons, which appears to depend on climatic conditions, and the frequency of spawning during the season, which may be characteristic of the species.

Among mature fish the proportion of breeding to non-breeding fish, in catches at different times of the year, indicates the duration of the breeding periods for the population as a whole. Data on the frequency of spawning by individual fish in natural waters are difficult to obtain and the only direct evidence so far comes from two marked fish recoverd by the Lake Victoria Fisheries Service. The first, a *T. esculenta* Graham, marked on 13th April, 1953, had fry in the mouth when marked, and when recaptured nine and a half weeks later (20th June, 1953) had eggs in the mouth. The second, also *T. esculenta*, when marked on 4th March, 1953, had fry in the mouth, and when it was recaptured seven weeks later (26th April, 1953) the ovary was ripening again. [*vide* 12]

Indirect evidence on the number of successive spawnings can be obtained from an examination of the ovaries. Evidence of recent spawnings can be seen in the ovaries as dark yellowish or brown flecks, and the number of size groups of small ova starting to develop indicates batches of eggs that should ripen in future spawnings. Thus, by examination of the ovary it can generally be seen whether a *Tilapia* is just starting or is in the middle of, or just finishing a spawning period. Observations on the ovaries suggest that many of the East African Tilapias, *T. esculenta, T. variabilis* Boulenger, *T. nilotica* (Linn.), *T. galilæa* (Artedi) and *T. leucosticta* Trewavas have three, four, or more batches of young in succession, but how long it may take for a particular batch of eggs to ripen is not known with any degree of accuracy. On the other hand among some *Tilapia* living in open water in Lake Nyasa, studies of the ovaries show that only one batch of eggs is normally produced per season.

De Bont[8] found that *T. macrochir* Boulenger and *T. melanopleura* Dumeril, in ponds in the Congo, bred throughout the wet season. *T. macrochir* produced fewer eggs than *T. melanopleura* but spawned every five weeks and up to six times in the year, whereas *T. melanopleura* spawned every seven weeks and only four times a year. There was evidence that the number of spawnings a year depended on the length of the rainy season and varied from year to year.

Brown and van Someren[6] found that in ponds in Kenya *T. nigra* (Günther) produced batches of young every four weeks and *T. melanopleura* every six weeks, but it was not known whether the same individuals were spawning each time.

Jubb[11] says of *T. mossambica* Peters in Southern Rhodesia "breeding activity starts when the water warms up and there will be as many as five broods in a season". In aquaria Baerends and Baerends-van Roon[4] found that *"T. natalensis"* (= *T. mossambica* Peters according to Trewavas[15]) spawned at frequent intervals, but they thought that the continuous succession of broods in Cichlids kept in aquaria was probably the result of aquarium conditions. Vaas and Hofstede[16] found that in ponds in Indonesia female *T. mossambica* laid eggs at intervals of 30–40 days and "spawning could take place the whole year round". According to the same authors females over 20 cm. long stopped laying eggs.

Aronson[2] found that for *T. macrocephala* (Bleek) in aquaria the time interval between successive spawnings varied from eight days to a year. In this species the spawning capacity

decreased with the age of the fish. This tendency for the frequency of spawning to decrease with age may very well hold good for other species of *Tilapia*.

Guarders and Brooders

According to the way they look after their young *Tilapia* can be divided into two main groups: "guarders" and "brooders". Only four species are known to be guarders: *T. sparrmani* A. Smith, *T. guinasana* Trewavas, *T. melanopleura*, and *T. zillii* Gervais. In these species the eggs are laid on specially cleared areas of the bottom or on rock or vegetation, to which they adhere. They are guarded, generally by both parents, until they hatch. On hatching the young are transferred to a specially prepared nest or to nest-holes and are there guarded by the parents until they are free-swimming.

The young of *T. melanopleura* and *T. sparrmani* have two pairs of "cement glands" on the head, described in *T. melanopleura* by Svensson[14] and in *T. sparrmani* by du Plessis[9]. These authors state that the young adhere to the sides of the nest by sticky threads secreted by these glands; the tails of the young are in constant vibration and circulate the water. Young *T. zillii* from a pond in Uganda were found to have bosses on the head superficially similar to those described as cement glands in *T. sparrmani*, and the young adhered to the bottom of the nest.

Daget[7] was able to give times for development; he found that *T. zillii* eggs hatched 48 hours after they were laid, and the young started to swim normally on the fourth day after hatching, by which time the yolk sac is practically resorbed. A striking thing about the young *T. zillii* found in Uganda was the small size of the yolk sac (1.5 x 1.0 mm.) compared to the length of the body (4.8 mm. total length). These *T. zillii* larvæ were so small that it seemed doubtful whether they were Cichlid larvæ. However, comparison of the size and colour of the yolk sacs with ripe ova of other *T. zillii* confirmed that they were *T. zillii*.

All the other *Tilipia* studied are "brooders". The eggs of these species are picked up by one of the parents almost immediately after they are laid and are brooded in the mouth until the young are free-swimming. The male in the West African species *T. macrocephala* (Aronson[1] and [2]) broods the young, but in the majority of brooding Tilapias, including all those from East and Central Africa, the female does the brooding. In *T. macrocephala* brooding by the male ends suddenly; once the young are ejected they are not recovered again. In the species in which the female broods, the end of the brooding period is much less definite because the young, after leaving the mouth, may be collected up again should danger threaten. As the young continue to grow, fewer and fewer are recovered by the female until brooding finally ceases.

The Number and Size of Eggs in different Species of Tilapia

In order to assess the number and size of eggs produced by *Tilapia* of different species, ova were dissected from the ovaries of ripe females. Fish from lakes, dams and ponds were examined. Aronson[1] found that in *T. macrocephala* the mature eggs are not stored in the ovary for more than a few hours and are normally laid almost immediately after ovulation. This also appears to be the case in the species examined personally. After ovulation, eggs tend to be lost very easily. Therefore, wherever possible, counts were made on ovaries which were just starting to ovulate.

The numbers of ripe ova from both ovaries of several species of *Tilapia* are given in Fig. 1 and Table I. It can be seen that the number of eggs produced is a function of the size of the female.

Data on the size of the eggs, given in Fig. 2 and Table II, show that the size of the egg varies from species to species and not with the size of the female.

The number of eggs relative to the size of the female, and the size of the eggs from fishes in stocked ponds and dams, generally fall into line with data for the same species from natural waters.

According to the species to which they belong, *Tilapia* have either many small eggs or few large eggs. *T. zillii* has the most numerous and smallest eggs, and the Lake Nyasa species have the fewest and largest eggs. When arranged according to the size and number of their eggs they fall into the following order: *T. zillii, T. galilæa, T. leucosticta, T. nilotica, T. variabilis, T. esculenta, T. karomo* Poll, *T. lidole* Trewavas, and *T. saka* Lowe.

It is immediately clear from the graph that the "guarder" *T. zillii* produces many more eggs than any of the mouth-brooding species.

Studies on *T. esculenta* and some other species suggest that the gonads may be larger and produce more eggs per spawning at the start of the spawning period than towards the end of the period. The 19 cm. *T. variabilis* in Table I which produced only 23 ripe ova was thought to be at the end of a spawning phase.

Some scattered observations exist in the literature on the number of eggs produced by *Tilapia*. Worthington[17] recorded a large *T. nilotica* female (length unspecified) from Lake Albert with 2,000 eggs in her mouth; he also records from a lagoon cut off from Lake Albert, three female *T. nilotica* between 12 cm. and 13 cm. long which were carrying 50 and 24 eggs and seven young fish respectively. Worthington said of these "the eggs of these small *ngege* (*T. nilotica*) are about the same size as those of the large *ngege* from the open lake, but the number in the broods is very small compared with the 2,000 from the mouth of the large *ngege*. Perhaps this is a modification due to the cramped environment." It would now seem that the small number of eggs in the small females is related to the size of the parents, and not related to the size or depth of the lagoon.

Baerends and Baerends-van Roon[4] stated that in *T. mossambica* "the number of eggs per female depends on its length; a female of about 15 cm. laid from 200–300 eggs". Vaas and Hofstede[16] added to this information for *T. mossambica* by giving a table of the number of eggs counted from the ovaries of seven females. They found 80 eggs in a female 8 cm. long, and 800 eggs in a 15 cm. fish; they noted, however, that "in Indonesia a *T. mossambica* female more than 20 cm. long will have ceased laying eggs".

Aronson[2] observed in *T. macrocephala* that the "larger females tend to lay more eggs". This species is rather exceptional in that the male broods the eggs, so the number of eggs which can be brooded depends on the size of the mouth of the male. Aronson records aquarium spawnings in which all the eggs laid could not fit into the male's mouth; in such cases the female would, after 10–20 minutes, collect and brood any eggs not already collected by the male. The relative sizes of male and female *T. macrocephala* which spawn together under natural conditions is not recorded.

De Bont,[8] working on *Tilapia* reared in ponds in the Congo, drew attention to the great difference in the number of eggs produced by *T. macrochir*, a brooder, and *T. melanopleura*, a guarder. In *T. macrochir* de Bont found 1,369 ova in the ovaries of one female and another had 973 young in the mouth. In *T. melanopleura* the ovaries of three females contained respectively 7,277, 5,755 and 5,182 eggs. De Bont does not mention the individual size of these females, but he notes that *T. macrochir* were starting to breed at 20 cm. and *T. melanopleura* at 22 cm. Brown and van Someren[5] record, however, that *T. melanopleura* introduced into ponds in Kenya bred irregularly and produced fewer fry per brood than did *T. nigra*, a mouth-brooder.

The maximum number of fertilized eggs recorded by the author from the mouths of different species are given below. Numbers of young are given if these were higher than the maximum number of eggs recorded for the species. It is interesting to compare these figures with data on the number of eggs from ovary counts (Fig. 1); in all cases the numbers recorded from the mouth are much lower.

T. leucosticta—414 eggs just hatching (female 26.5 cm. total length).

T. nilotica—705 eggs (female 30.5 cm.).

T. variabilis—286 eggs (female 25 cm.).

T. esculenta—711 yolked young (female 29 cm.).

T. karomo—65 eggs (female 20 cm.).

T. squamipinnis—287 eggs.

T. karongæ—324 young.

Baerends[4] records that when the female-brooding *T. mossambica* spawn in aquaria "often the male also takes up some eggs... usually these are eaten". If this also happens in nature and among the species listed here, it would help to account for the low number of eggs in broods compared with the number in the ovaries.

Tilapia eggs have a regular shape which is often characteristic of the species. The large eggs of most of the mouth-brooders are pear-shaped. In *T. zillii* the small egg is oblong; a similar oblong egg is recorded in *T. sparrmani*. [10]

The ripe ova of *T. sparrmani*, *T. zillii* and *T. galilæa* are olive green; in *T. melanopleura* they are yellowish; all the other species examined have bright yellow eggs. The significance of this difference in colour is not known,

but it may be an advantage for fish which leave their eggs on the substratum to have eggs which are not too obvious.

In all species where young are brooded they are retained until after occlusion of the yolk sac. The maximum sizes of young recorded by the author from the broods of different species are:—

T. leucosticta—6.3 mm. long, with yolk sac (303 in brood).

T. nilotica—13.5 mm. long, yolk sac occluded (18 in brood).

T. variabilis—13.5 m.m. long, yolk sac nearly occluded (38 in brood).

T. esculenta—15 mm. long, yolk sac occluded and young had started to feed (80 in brood).

T. karomo—11 mm. long, with yolk sac (2 in brood).

T. squamipinnis—30 mm. long (76 in brood).

T. saka—24 mm. long (18 in brood).

T. karongæ—15 mm. long (324 in brood).

T. lidole—52 mm. long (25 in brood).
58 mm. long (1 in brood).

T. shirana—10 mm. long.

It is clear from the size of young in which the yolk sac is occluded or nearly so, that *T. nilotica* probably does not brood young much larger than 13.5 cm. long, and *T. variabilis* and *T. esculenta* above 15 mm. long. Young are retained to a much larger size in the open-water species from Lake Nyasa, particularly in *T. lidole* in which young up to 52 mm. were often found. In the species which live out in open water, where there is little cover in the form of weed beds, the young are brooded to a larger size than are the young of inshore-dwelling species. Retention to a large size may also be related to the frequency of spawning; where there are many batches in succession these may provide a stimulus to cease brooding.

The young from the mouth of any single fish were all the same size and stage except in the very few cases noted here:—

A 20 cm. female *T. variabilis* trapped alongside a spawning ground in Lake Salisbury had one 13 mm. young and one newly laid egg in the mouth.

A 30.5 cm. female *T. variabilis* shot at Jinja, in Lake Victoria and examined by Mr. P. H. Greenwood, had young of very varying sizes in the mouth, one of 14 mm., 45 of 16–20 mm., 10 of 22–25 mm., one of 31 mm., and one of 33 mm. The ovary of this female was recorded as "completely spent, quiet". As this fish was unusually large for this species, it may be that she was almost past breeding age, yet retained the instinct to collect young in her mouth.

Among Lake Nyasa species, e.g. *T. squamipinnis*, young of different sizes were sometimes encountered. Proof that these were not all the offspring of the brooding female was forthcoming in one case where some *Haplochromis* fry were found by Lowe together with *Tilapia* fry in the mouth of one of these fish.[13] Vaas and Hofstede[16] reported a tadpole among a brood of fry removed from the mouth of a *T. mossambica* female. Where *Tilapia* are caught in seines and there is a general flurry as the net nears the shore, *Tilapia* fry seem to dart for shelter to the nearest mouth; at one beach on Lake Victoria where the water was very muddy, male and even immature *Tilapia* were caught with young in the mouth.

Discussion

The fundamental differences between the breeding biology of guarders and brooders should be appreciated. A point brought out in this investigation is the great number and small size of eggs produced by the guarder *T. zillii* compared with the small number and large size of eggs produced by the mouth-brooding species. *T. zillii* is now being introduced into Lake Victoria in considerable numbers and into dams.

In brooders, the ripe female makes only a very brief visit to the spawning grounds; she collects her eggs as soon as they are fertilized and then moves off to the brooding grounds. The males, however, remain on the spawning grounds, each one guarding a nest in his own particular territory; thus segregation of males and females occurs after spawning. The males that are left on the spawning grounds are able to fertilize eggs from a succession of females. As male fish can continue fertilizing over a long period, the number of eggs fertilized appears to be determined more by the number of ripe females than by the number of males. In the guarders, on the other hand, males and females pair before they spawn and stay together until their young become independent; thus the number of young produced must depend on the number of paired fishes.

Whether or not *Tilapia* introduced into lakes, dams, or ponds become well established will depend to some extent on what other species of fish are present, particularly predatory fish. In ponds there are generally few predators, so overstocking and consequent "runting" may present a serious problem. All species of *Tilapia* reared in ponds appear to start breeding at a very small size and to overpopulate the ponds very quickly. This has been noted in *T. mossambica* (Vaas and Hofstede[16]), *T. nigra* (Brown and van Someren [6]), *T. macrochir* and *T. melanopleura* (de Bont[8]) and from personal observations on *T. esculenta, T. variabilis, T. nilotica, T. leucosticta, T. zillii,* and species from Lake Jipe and the Pangani River.

T. zillii stocked in dams have grown to a large size, but in ponds they have bred freely and at a very small size. The large numbers of eggs produced by *T. zillii* compared with mouth-brooders can lead to particularly rapid overstocking. Ponds at Kisumu stocked in December, 1953, with 10 *T. zillii* 26–48 mm. total length, had produced about 9,000 *T. zillii* by September, 1954. De Bont[8] found in the closely related species *T. melanopleura* that, though it bred less frequently than *T. macrochir,* it produced about 7,000–8,000 fry a year compared with 4,000–5,000 produced by the mouth-brooder *T. macrochir.*

T. zillii introduced into Lake Victoria have grown extremely well, but it remains to be seen whether they can establish themselves successfully. In Lake Albert, *T. zillii* occurs together with *T. nilotica, T. leucosticta,* and *T. galilæa,* but it does not appear to be very numerous. In Lake Victoria there are many species of small fish (*Haplochromis*) that feed on eggs and fry; they may prey heavily on young *T. zillii.*

There are reasons to believe that the guarders, *T. sparrmani, T. guinasana, T. zillii* and *T. melanopleura* are probably closer to the original stock from which the various species of *Tilapia* evolved than are the brooders. Evolution in this genus seems to have been mostly along the line leading to a reduction in the number of eggs produced and the development of a brooding habit.

Summary

1. Fecundity has been defined as the number of young produced by an individual during its lifetime. Factors influencing fecundity are: length of breeding season, frequency of spawning during a breeding season, the number of eggs laid at a spawning, and the care taken of eggs before and after hatching.

2. According to whether they care for their young outside or inside the mouth, *Tilapia* can be classified as "guarders" or "brooders". Generally, guarders produce many small eggs and brooders fewer, large ones.

3. Only four species are known to be guarders: *T. sparrmani, T. guinasana, T. melanopleura* and *T. zillii.* The remainder are brooders.

4. Due to the different breeding biology of the two groups, the fecundity of guarders depends upon the number of paired fishes, whereas in brooders it is determined by the number of ripe females.

5. In the genus *Tilapia,* evolution appears to have been towards a reduction in the number of eggs produced, and towards the development of a brooding habit.

Acknowledgments

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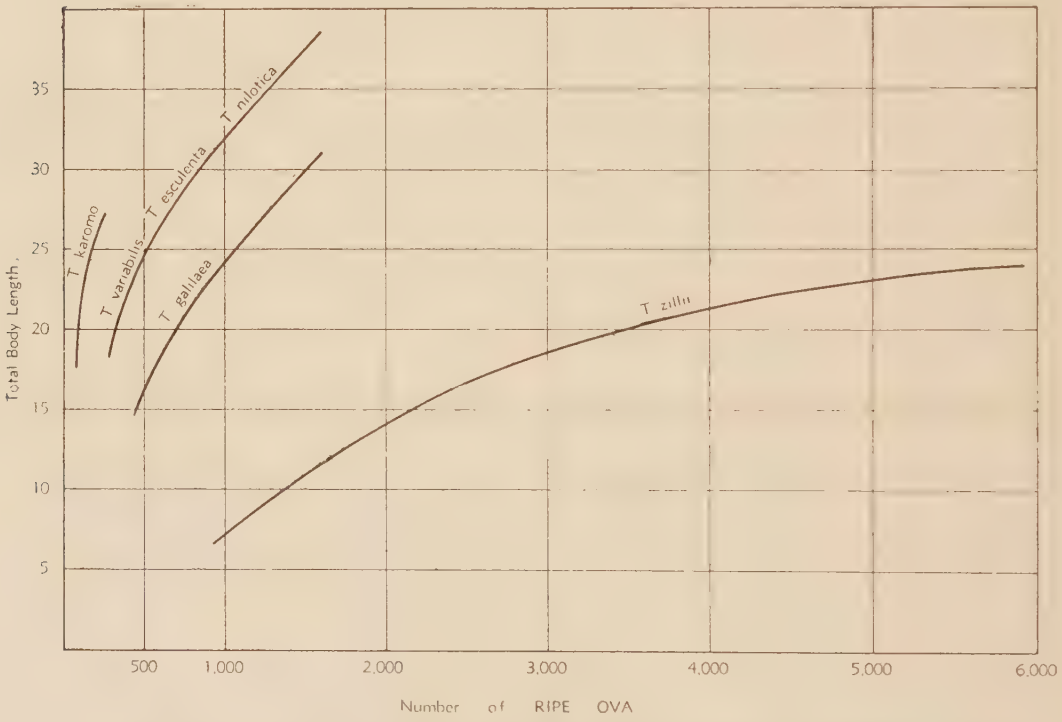

Fig. 1—Graphs drawn from data contained in Table II. These show the great number of eggs produced by the guarder T. zillii compared with the numbers produced by the brooders. This figure also shows that the number of eggs produced is a function of the size of the fish. Data for T. variabilis, T. esculenta, and T. nilotica fall on closely similar curves.

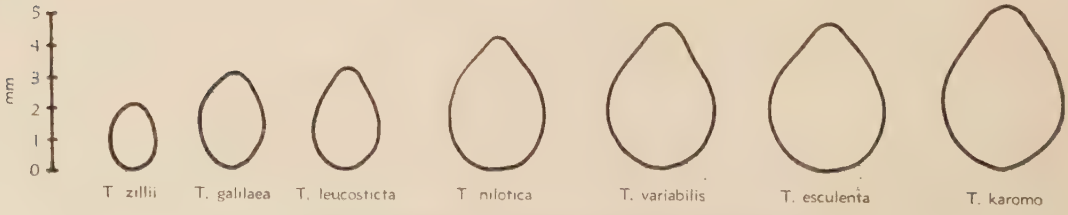

Fig. 2—The maximum size of eggs from several species of Tilapia

TABLE I.—THE NUMBER OF RIPE OVA OBTAINED FROM THE OVARIES OF VARIOUS SPECIES AND SIZES OF *Tilapia*

SPECIES	TOTAL BODY LENGTH OF FEMALE (CM.)																													
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	57
BROODERS																																
T. esculenta ..											324							379	429*	477	377*			758	660	1,085	904	951		1,672		
																		633		676	391*			995	897	1,095	1,374					
																				685	415			1,099	1,195	1,270						
																				817	696			1,128								
																								1,133								
T. variabilis ..													23*	323		282	496	364		430												
																		547														
T. nilotica ..											340				431					540		1,026		705	909		801	1,500			1,332	3,706
																											1,161					
T. galilæa ..										538	623			703			1,000	974						1,560								
T. leucosticta ..	99														498		642			950												
	102																															
	118																															
T. karomo ..												135	87		141		171				242											
													93		141																	
													135		152																	
													140		164																	
															175																	
															182																	
T. squamipinnis																				370–549												
T. saka ..																							276–330									
T. lidole ..																									364–542							
T. shirana ..														520–618																		
GUARDER																																
T. zillii ..		1,000			1,615						2,156		7,061			5,000 app.			5,711													

*End of spawning period.

TABLE II.—THE SIZES OF RIPE OVA IN DIFFERENT SPECIES OF *Tilapia*

The Total Lengths of the Females from which the Ova came are given in Brackets

Species	Maximum Size of Ripe Ova mm.	Minimum Size of Ripe Ova mm.
BROODERS:—		
T. esculenta	4·5 x 4·0 (36 cm. female)	2·5 x 2·0 (14 cm. female).
T. variabilis	4·5 x 3·4 (19 cm. female)	2·8 x 2·4 (24 cm. female).
T. nilotica	4·3 x 3·7 (29 cm. female)	2·8 x 2·5 (57 cm. female).
T. galilæa	3·0 x 2·2 (16 cm. and 20 cm. females)	—
T. leucosticta	3·3 x 2·4 (21 cm. female)	1·8 x 1·3 (7 cm. female).
T. karomo	5·2 x 4·5 (21 cm. female)	—
T. squamipinnis	4–5 mm.	
T. saka		
T. lidole		
T. shirana	3–4 mm.	–
GUARDER:—		
T. zillii	2·0 x 1·4 (25 cm. female)	1·1 x 0·8 (11 cm. female).

A STUDY OF THE MORE IMPORTANT SOILS OF ZANZIBAR PROTECTORATE

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A reconnaissance of the soils of Zanzibar Protectorate was previously reported (Calton, 1949). Since that time more field reconnaissance work has been done in Pemba, the second island of the Protectorate, and more analytical results are available on the soils of both islands. The present purpose is to bring this work together as a contribution to the study of tropical soils. The authors, in the order given, are responsible for the general pedology, agricultural experimentation and clay mineralogy aspects of the work.

Zanzibar Protectorate consists of two main islands, Zanzibar and Pemba, lying off the Tanganyika coast between latitude 5° and 7° south. They are respectively 640 and 380 square miles in area. According to Stockley (1928) Zanzibar is the more closely related to the mainland, being separated from it by a shallow channel and having a core of Pliocene sediments similar to those found on the mainland. Pemba, on the other hand, is separated from the mainland by a trough of Rift Valley dimensions and is mainly composed of older Miocene sediments which rarely occur on the East African coast. The older sediments of both islands had a westerly, mainland source. Both islands are fringed with Pleistocene limestones, this fringe being much larger in Zanzibar than in Pemba.

Climate is fairly hot (mean annual temperature 27°C.) and humid, Pemba having the higher rainfall (Pemba 77 in., Zanzibar 60 in.). Both islands receive more rainfall than the adjacent mainland; moreover, it appears to be rather more persistent throughout the year though there are two well marked rainy seasons. Distribution of rainfall in each island is fairly uniform, though it may be rather less, while evaporation may be considerably more, in their eastern halves.

Zanzibar has practically no river system though well water can be found nearly everywhere. Pemba has an intricate drainage system to the west of a central divide and a more open system with occasional small lakes to the east of the divide.

Zanzibar was surveyed incidentally during the course of other work, while two months were spent in Pemba entirely on soil survey (W. E. C.). Discussions with the native peoples during the survey brought to light many of the soil names used in this paper. They are adopted tentatively as pedological terms. About 100 soil pits were examined on each island and many opportunities were found for checking soil distribution at roadside cuttings, unlined wells and miscellaneous exposures.

Zanzibar Island

Zanzibar has three main groups of soils: the *mchanga*, a catenarily related group derived from non-calcareous sediments; the *kinongo*, red or potentially red soils of varying age derived from limestones; and the *kinamo*, a miscellaneous group of heavy soil derived from clays and marls. Their distribution is shown on the attached map and their relation to topography and geology is also illustrated.

It will be seen that the *mchanga* group occupies roughly the western third of the island with its redder types forming a central ridge. They are derived from the upper non-calcareous beds (sands and sandy clays) of the Zanzibar series and their colluvium.

The *mchanga* group of soils represents a red earth catenary complex. Although they are mapped in two groups this represents modal rather than exact distribution; for example, in the undulating reddish *mchanga* (Munsell Colour 2.5 YR 4/6) a dip in relief almost invariably produces a brownish to greyish type, and similarly in the flatter greyish *mchanga* (10 YR 6/2) a slight rise immediately produces a colour change in the direction of a redder soil. The *mchanga* are well-leached soils without soluble salts or calcium carbonate. The most freely draining member of the group

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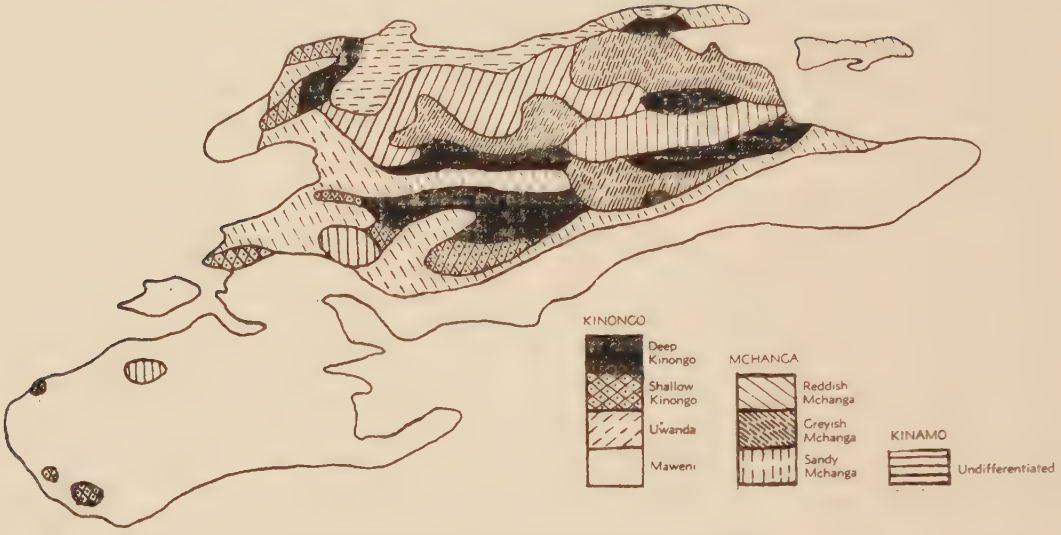


Zanzibar Island, showing distribution of soil types

is a very deep, reddish, sandy to rather heavy soil possibly with a few small ironstone concretions at depth. It changes imperceptibly through brown, orange-brown, yellowish-grey to grey with increasing drainage impedance and rising water table. The greyish bottomland type may have a somewhat peaty topsoil and occasionally some small black concretions above the water table level.

A considerable area of very sandy soil occurring along the west coast is mapped in this group, having most resemblance to the lowest catenary type of this sequence.

The reddish *mchanga* have a pH of about 5.5, which remains about the same or decreases to 5.0 at depth. Exchangeable calcium is of the order of 2 to 3 m.e. per 100 g. of soil and is without significant variation in depth. Organic carbon is usually less than 1 per cent in the top foot and falls to about 0.5 per cent in the second foot. Truog phosphate is of the order of five parts per million P throughout the profile though it may be slightly more than this in the top six inches. The greyish *mchanga* give similar data except that pH may be lower, 4.5 to 5.0.

The clay mineral composition of two reddish *mchanga* and one greyish *mchanga* were examined by means of powder and aggregate X-ray technique. One of these, a freely draining soil of full red colour from Kizimbani, was found to contain kaolinite with a minor quantity of goethite while the other two, representing the extremes of the local catena at Selem, consisted largely of kaolinite with traces of goethite and vermiculite.* It would seem that the disappearance of vermiculite and the greater development of goethite in the Kizimbani soil are the result of more effective leaching.

In the *mchanga* group it is likely that leaching solutions pass more or less laterally across the sequence. For this reason a difference in clay mineralogy was expected between the reddish *mchanga* at Selem and its greyish associate. Such a difference was not found, perhaps because of the quantitative limitations of the X-ray method.

The *mchanga* as a group might be regarded as the "normal" soils of the island developing on the mixed parent materials usually found in coastal areas. This general type, though not so frequently red in colour due to a flatter topography, is the dominant soil of the adjacent mainland.

The next group, the *kinongo,* covers practically the remainder of the island. The deeper types occur as low ridges, in roughly parallel formation, mainly in the centre of the island in contact with the *mchanga,* while the shallower types cover the flat country to the east and south-east. The components of this

* Estimates given in the text of the amounts of minerals present refer to the crystalline component of the soil—clay only.

group show considerable variations but they fit, with one anomaly (the *uwanda* type) a maturity sequence derived from limestones. They do not show catenary differentiation though the topography is often irregular. This seems to be due to an entirely vertical leaching régime as evidenced by a water table within the parent rock and below the soil profile and the absence of a river system. The degree of maturity of the *kinongo* soils is determined by the time during which parent material has been exposed to weathering. The four clearly defined types in this group, mainly without transitional types, reflect a stepwise emergence of the island.

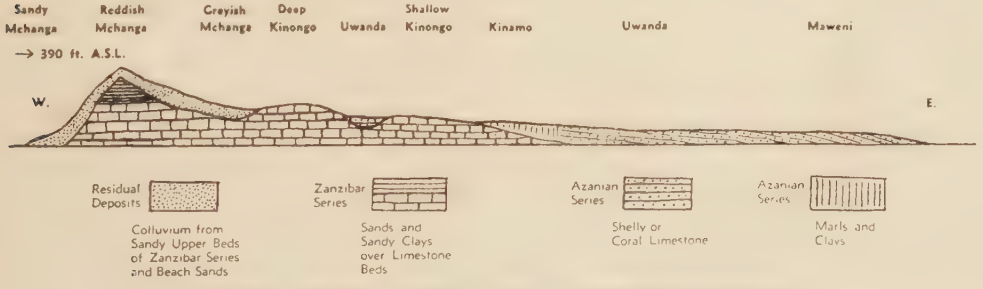
The most mature soil of this group—the *deep kinongo*—is a rather heavy loam of full red colour (10 R 3/6), with a remarkably uniform profile. There may be a slight increase of clay content with depth due perhaps to diminishing organic matter. There is no suggestion whatever of illuvial horizons and the change from soil to rock is sharp. Arbitrarily, any *kinongo* deeper than 6 ft. was regarded as a *deep kinongo*. The next type in the sequence, the *shallow kinongo*, has very similar characteristics but the depth of profile over parent rock is of the order of 3 ft. It is a shade less red (10 R 4/6) than the *deep kinongo*. The third type—the *uwanda*—is a dark-coloured (5 YR 3/2) loamy soil about 1 ft. deep over limestone. At this stage there is a change from the more compact limestones of the Zanzibar series to the highly porous shelly or coral limestones of the Azanian series. The final member of the *kinongo* group, though now without perceptible red colouring, is a vestigial type, the *maweni*. This soil consists of pockets of black humic material in crevices in the parent limestone.

The *kinongo* group show increasing pH, exchangeable calcium, organic carbon and "available" phosphate as the profile becomes shallower which is in accordance with maturity relationships. Some topsoils gave the following data:—

	pH	Organic Carbon	Exch. Calcium m.e. per 100 g.	Truog Phosphate (P. p.p.m.)
Deep kinongo ..	6·4	1·9	12·0	43
Shallow kinongo	6·8	2·8	25·5	148
Uwanda ..	7·0	6·8	45·5	184
Maweni ..	8·0	20·3	high	107

Though profile data are few there are indications that even in the *deep kinongo* pH does not fall much below 6.0 nor exchangeable calcium much below 6 m.e. per 100 g. at depth.

Clay mineral determinations indicate uniform composition down to 8 ft., the greatest depth sampled, in the *deep kinongo*. The clay of this soil consisted of kaolinite with a small amount of goethite. The *shallow kinongo* has similarly a uniform clay character throughout the profile and is largely kaolinite with traces of vermiculite and goethite. Calcite is the main constituent of the parent material of this profile but traces of kaolinite and hydrous mica were also observed. Boehmite accounts for more than half the clay fraction of the *uwanda*, the remainder being vermiculite and kaolinite. Its parent material is of similar composition to that of the *shallow kinongo*. It is apparent that increased amounts of kaolinite, perhaps derived from the breakdown of vermiculite, are found in the more mature soil-clays of this group. Though the *uwanda* is predominantly sesquioxidic in its clay fraction the presence of vermiculite could endow it with a considerable base-holding capacity. Its highly sesquioxidic nature is probably related to the porosity of its parent material which permits very rapid leaching, an effect not observed in the deeper kinongos which are derived from more compact limestones.



Zanzibar—schematic relation of soils to topography and geology

The *kinongo* group as a whole shows a marked redness unrelated to topography. Although, like the *mchanga*, they are kaolin-type soils they retain a link with parent material. If they had not been formed from easily weathering pervious parent material they would doubtless have shown some of the characteristics, such as topographic colour changes, concretion formation, subsoil mottling, associated with the sluggish seepage of water through soils. The deeper kinongos suggest an advanced form of "terra rosa".

The third group—*kinamo* soils—are found in three isolated areas. The largest area, in the north of the island, consists of grey clays to sandy clays, derived from clayey parent materials. This area is little used for cultivation and it is suspected that it is too intractable, perhaps due to a general shortage of calcium carbonate, for the native hoe. The remaining *kinamo* areas consist of small patches at Cheju in *uwanda* country in the centre of the island, and at Muyuni in the *maweni* in the south-east. The *kinamo* are all heavy, cracking soils. They are without perceptible catenary differentiation, being generally flat and, even where topography is somewhat irregular, the inherent clayey character dominates the drainage régime.

At Cheju the whole profile is non-calcareous and pH at the surface is 4.8, falling to 4.2 mid-profile and rising again to 4.8 at 6 ft., where some soluble salts, probably mainly gypsum, are found. Exchangeable calcium is of the order of 6 m.e. per 100 g. at the surface, falling slightly and then rising again as with pH. Truog phosphate is about 15 p.p.m.P. at the surface, being maintained at depth. The organic matter is not high. The overall colour of this soil is brown (10 YR 5/3). The Muyuni *kinamo* is calcareous at depth and shows pH increasing down the profile from 5.7 to 8.3. No soluble salts are present and exchangeable calcium is high at the surface—18 m.e. per 100 g.—falling mid-profile and then increasing to the calcareous horizon. The top 2 ft. of this soil are dark coloured (10 YR 2/2) while the main profile colour is light olive brown (2.5 Y 5/4).

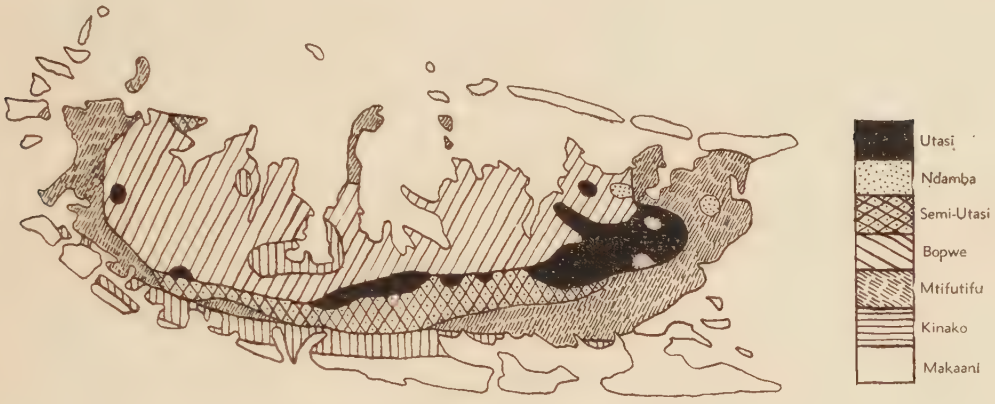
The major proportion of the clay fraction of the Cheju profile at 6 ft. down consists of montmorillonite with rather less kaolinite and a trace of boehmite. Higher up the profile at 4 ft. and 2 ft. kaolinite has displaced montmorillonite as the main constituent, while the amount of boehmite remains unchanged. The Muyuni profile had a uniform clay down to 5 ft. consisting of approximately equal quantities of montmorillonite and halloysite. A very small area of *kinamo* at Selem, too small to map, had a clay fraction at 7 ft. consisting of approximately equal quantities of kaolinite and montmorillonite with traces of calcite and goethite while at 2 ft. kaolinite was dominant and only minor amounts of montmorillonite were found.

Developing on secondary clayey materials the *kinamo* have formed considerable amounts of kaolin minerals in spite of impeded drainage. In the case of the Muyuni soil it is probable that some factor has improved drainage sufficiently to give uniform weathering in depth. The soils of this group are classed together on physical properties which are reflected in a significantly montmorillonitic clay character. It is evident that in future work it will be necessary to differentiate them on fertility and other grounds.

Pemba Island

The soils of Pemba do not fall into well-defined groups, and with few exceptions are markedly different from those of Zanzibar. In outline there are four upland soils—*utasi, ndamba, semi-utasi* and *bopwe*—differentiated mainly on geomorphology; and three lowland soils—*mtifutifu, kinako, makaani,* differing mainly in parent material. Two of these soils are not unlike those of Zanzibar. The *kinako* is closely related to the calcareous *kinamo*, while the *makaani,* which perhaps should be split into two types, have a rocky phase similar to the *maweni* and a deeper phase equivalent to a very shallow *kinongo* rather than an *uwanda.* The distribution of Pemba soils is shown on the attached map and an outline is also given of their relation to topography and geology.

The *utasi,* though most extensive in the north of the island, can be traced along a central line of plateau remnants. It is a deep grey to brownish grey (2.5 Y 6/2) firm sandy soil with a tendency to cementation (a "fuwe" horizon) at depth. The cementing material is possibly silica. pH is fairly constant at about 5.5 but may be a little higher in the topsoil. Organic matter is low and exchange capacity amounts to 4–6 m.e. per 100 g. Calcium accounts for about 66 per cent of the exchangeable bases and potassium may be as high as 8 per cent. The clay composition is uniform down to 7 ft. and consists very largely



Pemba Island, showing distribution of soil types

of kaolinite with some goethite and perhaps gibbsite. Qualitative mineralogical examination of the sand fractions of *utasi* soils shows mainly quartz with some felspars and minor accessory minerals, most grains showing a fair degree of rounding.

The *ndamba* is usually associated with the *utasi* though there are two outlying patches, one in the *bopwe* and one in the *mtifutifu*. Probably the patch of *ndamba* in the *bopwe* area was once connected with the *utasi*, the intervening *bopwe* having formed by the cutting back of the *utasi* plateau. The *ndamba* patch in the *mtifutifu* indicates that this type can occur wherever, perhaps by water sorting, the parent material is highly quartzic. The *ndamba* has a practically level surface and is characterized by a heath vegetation—"giant heather" (*Phillipia mafiensis*) being the dominant species. So far as can be seen there is no difference in height between the *ndamba* and the *utasi*. The upper layers of the *ndamba* consist of a pale grey coarse sand while at about 3 ft. there is a black organic cemented layer. This layer may induce waterlogging in the wet season. pH is about 4.0 and there is an almost complete absence of exchangeable bases. In the A and B horizons the clay fractions consist of quartz with traces of boehmite and perhaps anatase. The *ndamba* is considered to be an organic podzol.

The *utasi*, and generally the *ndamba*, appear to represent an old marine platform and owe their main characteristics—level, largely undifferentiated sandy nature—to this type of origin. Though in general these characteristics lead to a favourable soil moisture régime these soils are likely to vary in nutrient levels due to marine sorting and indeed this is shown in the sporadic occurrence of the particularly infertile *ndamba*.

The *semi-utasi* soils occur as a strip to the east of the *utasi* plateau remnants and are probably related to them. It may also be of significance that in places the *semi-utasi* abut on the less pervious *kinako*. The *semi-utasi* closely resemble the *utasi* at the surface but have some grey and brown mottling at depth. There is the further difference that the *semi-utasi* country is undulating. Reaction in this type is about the same as in the *utasi* but exchange capacity is a little higher and the clay fraction which is uniform in composition down to 6 ft. is largely kaolinite but with a small amount of montmorillonite.

This type appears to be the most like Milne's mottled clays (Milne, 1936) but none of the profiles examined showed within 6 ft. of the surface the disjointed character—red earth type over heavy clay—which he mentions. It may be argued that this type is more dissected than the *utasi* because it is less water-absorptive. Whether it is a more silicious variant of the *utasi* due to the check of leaching solutions by underlying impervious material or whether it is derived from originally more clayey sediments is not clear.

The *bopwe* occupy the remaining high level country to the west of the *utasi* and *semi-utasi*. Contrasting with all the other soil zones the topography is sharply dissected. These soils have developed in the basal Miocene sediments which, except for some buckling, are horizontally bedded. Narrow bands of coarse sand,

fine sands, silts and silty clays are common though the upper soil layers (0–4 ft.) are generally fairly homogeneous probably due to soil creep. The topography in fact is too sharp for normal catenary development and leads to run-off of water, mixing of the upper layers and the maintenance of a relatively shallow soil profile. The *bopwe* are generally reddish-brown (7.5 YR 5/6) loams from ridgetop to stream edge, though there are some dark-coloured wet alluvial-colluvial bottom lands of minor extent.

The *bopwe* have a pH between 5.5 and 6.0 while exchangeable calcium varies from 1 to 7 m.e. per 100 g. The clay fraction, which is uniform to 5 ft., consists of kaolinite with traces of goethite. Perhaps the most significant fact about these soils is their perpetually maintained shallowness.

The *mtifutifu,* the first of the low-level soils, abuts on all the high-level types. It is extensive in the north-east and the south but tends to encircle the whole high-level block. It is a deep brownish-grey (10 YR 6/2) sandy soil without marked profile differentiation. It resembles to some extent the *utasi,* but is without the tendency to cementation at depth, and the surface is more irregular, and occasionally dark-coloured bottomland types may be found. Organic matter levels are very low in this type, probably due to the drier conditions and the sparser vegetation cover. pH may be as low a 4.5 at the surface increasing to 6.0 at depth. Exchange capacity is of the order of 8 m.e. per 100 g. and in one profile a considerable content of exchangeable magnesium was found. Clay minerals which are uniform down to 7 ft. are similar to those of the *utasi* and the *bopwe* and consist of kaolinite with a trace of goethite.

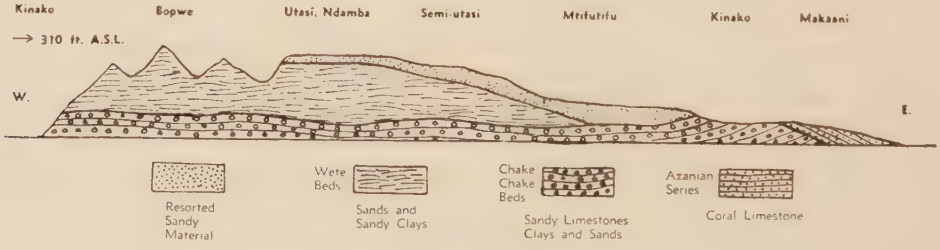
It seems likely that the *mtifutifu* has been derived as an off-shore deposit from erosion products of the more elevated soils.

The *kinako,* derived from the calcareous Chake Chake beds, occupy a well-defined narrow strip along the east coast and two isolated areas within the *bopwe.* The eastern strip is probably the result of the exposure of marly beds by faulting, while the larger western area probably owes its origin to the removal by erosion of the overlying non-calcareous beds.

The *kinako* are usually dark grey-brown (10 YR 4/2) cracking clays with calcium carbonate at depth. pH ranges from about 6.8 in the topsoil to 8.3 at depth with over 20 m.e. per 100 g. exchangeable calcium at the surface increasing with depth. One profile showed the clay fraction to be largely montmorillonite with kaolinite increasing and montmorillonite decreasing towards the surface. Traces of goethite were also found at all levels. The underlying rock consisted mainly of calcite with some montmorillonite and goethite.

As with the *kinamo* the most significant property of the *kinako* is their montmorillonite clay character. There is similarly a breakdown of montmorillonite to kaolinite in the upper layers.

The *makaani* festoon the island and are the main soils of the outlying islands and peninsulas. They are shallow dark brown (7.5 YR 3/2) humic soils, ranging from vestigial crevice soils to continuous soils a foot or so deep on recent compact limestones. Reaction is neutral and exchangeable calcium content is high. They may contain 10 per cent or more of organic carbon. They differ fundamentally from the *uwanda* in the mineralogy of their clay fractions, one profile (6 in. deep) being found to have a clay fraction consisting of anhydrite partly altered to gypsum with traces of micaceous material. This suggests that they are very young soils indeed.



Pemba—schematic relation of soil types to topography and geology

Soil Utilization and its Problems

In regard to soil utilization, some of the main soil types are clearly differentiated by the crops, especially the permanent crops, which can be grown on them. The *maweni* and the

rocky *makaani* support a natural low scrubby bush and, when cleared, the pockets of soil may be utilized for a limited number of seasons for a fair range of annual crops. But these soils can supply neither the root room nor the retained moisture needed for the easy establishment of permanent trees. Even the *uwanda* soils of Zanzibar, which may be a foot or more deep, will not support the more exacting permanent trees although a small variety of uncultivated trees are usually present. These are remarkable mainly for their ability to survive the frequent fires which sweep through these grassy plains. Lack of moisture and mineral fertility difficulties combined with the fire hazard render the *uwanda* areas practically useless to the cultivator of annual crops, although recently a start has been made in utilizing the *uwanda* sward for beef production. An increase in soil depth provides sufficient root room and moisture to support citrus, a most typical crop of the shallow and deeper *kinongo* soils of Zanzibar. But cloves, the main tree crop of the Protectorate, cannot be supported by the shallower *kinongo* soils, whereas coconuts are grown without difficulty. In the remaining types soil depth is sufficient for the tree crops, but unsuitable moisture régime and possibly a rather lower level of fertility provide the reasons why the clove, a much more selective tree than the coconut, is unable to grow on the *mtifutifu* in Pemba and the grey and yellow *mchanga* in Zanzibar. Similarly, a high water table, sluggish drainage and frequent flooding make even the coconut unable to thrive on the *ndamba* and some of the *kinamo* and *kinako* soils. The *ndamba* rarely produce any crop.

The annual crops are less selective, although rice, even when upland varieties are grown, is obviously not at its best on soils which are not water-retentive. For this reason rice is not grown on the *maweni* and *makaani* soils nor on the *uwanda*. The *kinongo* soils are very rarely planted to rice. Rice grows best on the water-retentive, heavy *kinamo* and *kinako* soils and almost as well on the *mtifutifu* and some of the *mchanga* soils, especially where the water table is high. On these latter soils in particular the value of organic dressings and compost is most marked with rice, since one of the main effects of such dressings is to increase the moisture retention of the soil. This is also demonstrable with root crops on the *shallow kinongo* soil where dressings of compost can increase the yield of yams four- and five-fold. Annual crops may be grown on the *maweni* and rocky *makaani* under a system of shifting cultivation, and their planting is preceded by felling and burning the secondary bush. This burn undoubtedly provides a temporary but very considerable increase in fertility which cannot, up to the present, be equally provided by common mineral fertilizers or by composting. The effects of the burn on the *maweni* have been observed for as long as four years afterwards. Some areas of deeper *makaani* in Pemba have supported a semi-permanent stand of bananas in a condition of exceptional vigour for several years without any appreciable addition of manure. This is obviously related to the more normal development of this soil as compared with the advanced desilication on porous parent material in the *uwanda* or the limited development of the rocky soils.

The change from *maweni* to *uwanda,* which may occur, is generally feared. The pattern of shifting cultivation practised on the *maweni* is intended to ensure the rapid and complete regeneration of the bush after the last crop is reaped. When bush begins to give way to grasses, possibly as a result of too lengthy a period of cropping, much reduced fertility and annual fires follow the grass. Thereafter, although a more continuous soil is evident, cropping is much less successful. It would appear that important soil changes quickly set in.

Rice and other annual crops such as maize, sorghum and certain pulses, provide useful indicators of clearcut differences in the fertility status of the main Zanzibar soil types. On one hand the *kinongo* series, including the *uwanda,* appear relatively rich in phosphates and crops do not respond to phosphate manuring. On the other hand the *kinamo* and *mchanga* soils of all kinds are apparently deficient in phosphate, and its application, particularly to *mchanga* soils, leads to very great crop yield responses sometimes of the order of over 200 per cent. The *mchanga* group responses to phosphate are in accord with general East African experiences on soils of similar parentage. As regards the *kinongo* soils' apparent richness in phosphates, it is clear that a shallow limestone-derived soil might well contain much phosphate of marine origin, but it is not so clear why this should persist in adequate amounts in deep red soils in which visible limestone lies at great depth.

The respective potash status of each group of Zanzibar soils is almost as clearcut. The

mchanga and *kinamo* soils do not respond to potassium when annual crops are grown, although there is evidence that continued cropping of *mchanga* soil by permanent crops, such as cloves or even by semi-permanent crops such as pineapples, may cause a temporary shortage of potash. This general lack of potassium responses is not fully understood. Exchangeable potassium may be practically undetectable by ordinary methods of analysis. It would appear that potash reserves in *mchanga* soils exist in felspars and that, under the climatic conditions pertaining, they weather sufficiently rapidly for most crop needs.

On soils of the *kinongo* series the response to potassium is somewhat obscure. Certain broad-leaved crops, such as sunflowers and cotton, have given yield increases due to potash whereas cereals, such as maize and sorghum, have shown the effect of potash vegetatively rather than by yield. On the other hand there is clear evidence that cereal crops recover from setbacks, such as those caused by certain insect pests, much more readily when potash is present and in these circumstances yields are much improved. Moreover the value of potash to cereals on *kinongo* soils is sometimes manifested in positive interactions with nitrogen.

The chemical fertility of the *kinamo* soils should on general grounds be high. The response of crops on these soils to phosphate but not to potash is similar to the *mchanga* soils, but the demand for phosphate is much less.

The Pemba soils are, on the whole, more fertile than those of Zanzibar except, perhaps, for the deeper *kinongo* types. This enhanced fertility must be attributed to other effects—possibly greater or more varied mineral reserves augmenting their low exchangeable nutrients with perhaps generally damper soil conditions assisting mineral breakdown. There is no clear distinction between groups of soils needing phosphates but not potash, such as is seen in Zanzibar. Cloves grow well on *utasi* and *semi-utasi* soils and equally well on the *bopwe* which probably owes much of its fertility to its truncation, which keeps fresh minerals within root range, and also to the water-retaining ability, in spite of the steep slopes, of the heavier *bopwe* soils.

Coconuts, which are less profitable than cloves, are little grown in Pemba. They are mainly found on the *mtifutifu*. Rice and other annual food crops are crowded into the valleys in the clove areas, but are more widely planted in the *mtifutifu* and *kinako* soils to the east. These food crops almost always respond to phosphates and less frequently to potash.

Where food crops are grown on the *utasi*, *semi-utasi* and *bopwe* soils minor and irregular responses to potash may be observed and it is clear that no Pemba soil, except possibly the *mtifutifu*, has the relatively high potash availability found in the *mchanga* soils of Zanzibar.

Responses to nitrogen, which sometimes very considerably increase yields, occur in all the soils of the Protectorate and on all the crops tested both permanent and annual. Exceptions to this general rule have been observed when nitrogen is applied lavishly to annual crops growing on soils of low moisture-retaining capacity which cannot support the vigorous vegetative growth caused by the fertilizer. For this reason it is often best to apply nitrogen at the beginning of the wet season when there is sufficient moisture to support the increased growth. The value of nitrogen is frequently manifest in marked positive interactions with either phosphate or potash on soils respectively deficient in these elements. On certain *kinamo* soils nitrogen is apparently only of benefit in this manner, and this may also be true of healthy cereals on some *kinongo* soils.

The part played by trace elements in the fertility of the Protectorate's soils is little understood. The *uwanda* soils have sometimes provided evidence of mineral deficiencies but this evidence is far from consistent. Iron deficiency has been observed, and it is possible that other trace elements may be sufficiently scarce in the herbage at certain seasons to cause unthriftiness in grazing animals. *Mchanga* soils containing excess manganese may apparently cause nutritional disturbance in some crops and cacao is sometimes difficult to establish on this type of soil.

ACKNOWLEDGMENT

We have to thank Mr. A. K. Briant, Director of Agriculture, Zanzibar, for his close interest in these studies and for his permission to publish them.

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A NOTE ON THE APPEARANCE OF TWO NEW STEM RUST FORMS IN EAST AFRICA

By H. C. Thorpe and A. D. S. Duff, Department of Agriculture, Kenya

(*Received for publication on 21st March, 1955*)

In the rust survey carried out annually in East Africa to determine the prevalence of the various forms of black stem rust, *Puccinia graminis tritici,* material from two sources in the 1953 survey gave reactions which could not be explained on the basis of the 12 known forms.

The first of these came from the Kenya wheat 360.H growing in the breeding cages at the Plant Breeding Station, Njoro, and the second from a field crop of the wheat R.64 on the Kinangop Plateau. These are both established varieties. R.64 is a single plant selection from the hard red Canadian spring wheat D.C. x Ceres 721 and had previously shown resistance to all 12 of the known forms of stem rust. The variety 360.H had shown susceptibility to the form K.11 only. The anomalous reaction on the differentials of the rust from the 360.H and the presence of rust on R.64 in the field, both strongly suggested that one or two new physiologic forms of stem rust had appeared.

This was the subject of further tests at Njoro, as a result of which it was confirmed early in 1954 that two new forms, K13 and K14, had, in fact, arisen. Their reactions on the differentials are as follows.

It is of interest to note that with R.64 the field attack in both Kenya and Tanganyika was only mild, and it may be that the variety has some field resistance to this rust form. Be this as it may it is unfortunate that this rust has attacked a number of new and promising varieties in the course of multiplication, which were shortly due for release to farmers; and it is almost certain that this race will exhibit a virulence exceeding that of K9 and the old race K4, which did so much damage to wheat in Kenya in earlier days. This rust, K14, is expected to cause a great deal of trouble in the course of the next few years. Fortunately, K13 does not appear to be particularly virulent on tests so far completed.

Differential	K.13	K.14
Kenya Governor	1	3
Einkorn	3	1–2
B.256.G.	3	4
Reliance	0	3
58.F.	4	4
Rhodesian Sabanero ..	4	3–4
117.A.	3	3–4
184.P.2.A.1.F.	1	1
367.BR.1.D.4.F.	1	1

The advent of K14 will necessitate a review of the breeding work and the probable discard of all material showing susceptibility to it. New crosses are already under way which show seedling resistance to this rust form; but it will be some considerable time before they get to the stage of release. In the meantime, the appearance of this virulent and destructive form must occasion a serious setback to the breeding programme.

A more comprehensive article on the stem rust position in East Africa is being prepared and will appear in a later number of this JOURNAL.

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This is the French edition of "A handbook of Hides and Skins", by Dr. I. Mann, which was reviewed in this JOURNAL, Vol. 18, July, 1952, page 8.

TIV FARM AND SETTLEMENT, by P. Bohannan. Colonial Research Studies No. 15. Published by H.M. Stationery Office, 1954. Price £1 7*s*. 6*d*.

This is a detailed study by an anthropologist of the agricultural practices and customs of the people of Tivland in Nigeria. The text occupies 83 foolscap pages and includes photographs of the methods of cultivation.

FERTILIZING FLUE-CURED TOBACCO, issued August, 1954, and obtainable from the Tobacco Research Board of Southern Rhodesia.

The recommendations in this farmer's booklet of 16 pages are the result of fertilizer experiments which have been carried out during a number of years. In the 1953–54 season alone, 600 fertilizer treatments were tested, and these trials have enabled more specific recommendations to be made.

CATALOGUE OF WILD MAMMALS OF THE SUDAN occurring in the natural orders Artiodactyla and Perissodactyla, by P. Z. Mackenzie. Mimeograph, obtainable from the Natural History Museum, P.O. Box 178, Khartoum, Sudan. Price 40 piastres Egyptian.

This booklet of 21 pages includes an index of species, and a classification of the mammals under order, section, family, genus, and species. The popular names are given in clear type so that it is easy to work backwards from the common names. Three maps of the Sudan are folded in as appendices: a survey map; the main agricultural regions; and a map which gives the main ecological regions of the Sudan.

CANNED FOOD. A summary of figures of production, consumption and trade relating to the principal canned foods. Compiled in the Intelligence Branch of the Commonwealth Economic Committee. London, 1955. H.M.S.O. Price 5*s*.

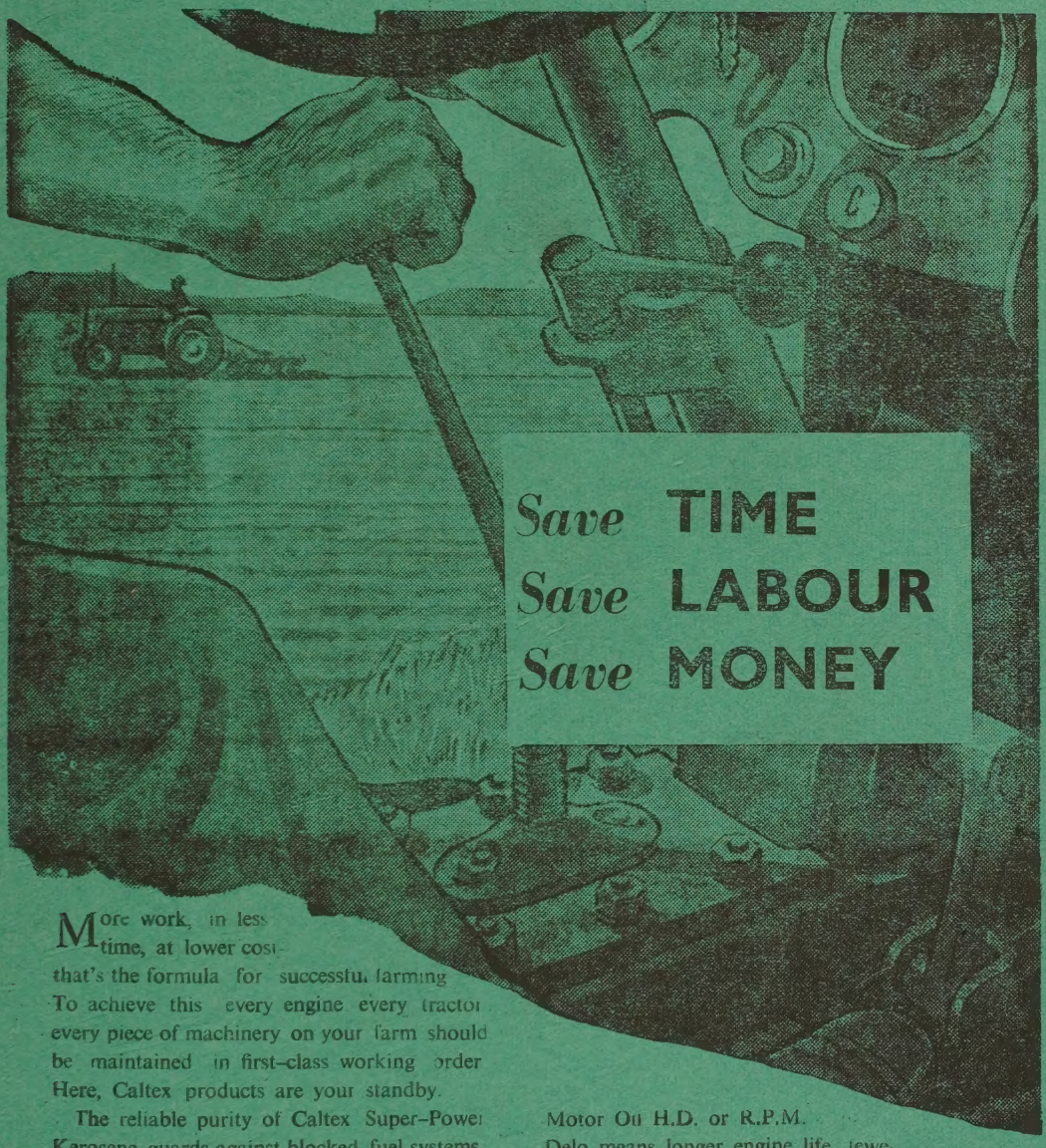
PLANTATION CROPS. A review of production, trade and consumption relating to sugar, tea, coffee, cocoa, spices, tobacco and rubber. Compiled in the Intelligence Branch of the Commonwealth Economic Committee. London, 1955. H.M. Stationery Office. Price 5*s*.

A REPORT ON CACAO RESEARCH, 1953 published by, and obtainable from, The Imperial College of Tropical Agriculture, Trinidad, British West Indies; London Office, 40, Norfolk Street, London, W.C.2. Price 10*s*. 6*d*.

Papers in this Annual report include results of the Anglo–Colombian cacao-collecting expedition; a new technique in the vegetation propagation of cacao; studies on the cacao beetle and on the incidence and control of witches' broom disease; field trials on shade, fertilizers, and cultural methods; nitrogen partition in the cacao leaf; and a description of a new solar fermentary.

THE SISAL INDUSTRY OF TANGANYIKA by Sir Eldred Hitchcock, C.B.E.

A pamphlet reprinted from Tanganyika Trade Bulletin No. 1 April/May, 1955, and obtainable from the Tanganyika Sisal Growers' Association, Tanga, Tanganyika Territory. It gives a concise summary of the history of sisal, its growing and processing, the research and labour organization, and the economic position of sisal in Tanganyika and in world markets. While the subject matter has been very greatly condensed, most aspects of the industry have been included.



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